IDENTIFYING TOOLS, MATERIALS AND ADHESIVE METHODS USED IN THE PRIMARY SCHOOL AND FACTORS INFLUENCING THE OPPORTUNITIES TO USE THEM

A thesis submitted by

Alwyn Powell

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Abstract

The focus of this study was to identify when tools, materials and adhesive methods were introduced into the primary school and to explore the links to the development of fine motor and manipulative skills. A significant phase in child development is located in primary school, which in Queensland schools begins in the prep year and progresses through to year six (ages five to twelve). The formalisation of the curriculum and growing independence of children's movements means greater access to a wider variety of ideas, understandings, skills, tools and materials as the children progress through the primary school years. It is a child's right to learn about and access new tools, materials and adhesive methods.

There are expectations that cognitive and creative skills inherent in the STEAM discipline areas will become critical in formal education as part of the skills for the twenty-first century. Paralleling the growth in discipline knowledge is the continued growth of curiosity and wonder, critical and creative thinking, collaboration and communication as well as the physical development of the child, including greater control and competence in fine and gross motor skills. Teachers are responsible for providing learning experiences and opportunities that enable the child to develop the strength, dexterity and competence in the use of tools to engage with materials in safe and novel ways.

This study investigated the specific tools and materials accessed throughout primary school via a quantitative survey phase, then followed by a qualitative phase using semi-structured interviews. The survey was completed by one hundred and seventy-two individual teachers (N=172). An initial analysis of this data provided questions for the targeted interviews (N=12).

This study calls into question the experiences and opportunities offered to children in the primary school to learn and grow with the use of tools, materials and adhesive methods as an avenue to explore and develop their curiosity and create new and innovative products for their satisfaction and future employability opportunities. It found that the identified range of tools and materials do not match with current trends in skills and knowledge required for the twenty-first century. Teachers identified limited funding, time, professional skill development and narrowing of the

curriculum as major reasons for reduction in the provision of experiences in hands-on activity.

The narrowing focus of educational experiences does not reflect the spirit of the Convention on the Rights of the Child, especially article 29 UNICEF (1989), in physical development nor the practical experiences needed to enhance learning in the science, technology, arts or mathematical fields touted as the disciplines critical for the twenty- first century. The failure of education authorities to ensure effective learning opportunities are enacted has led to the inability of children to effectively develop competencies and strength in fine motor control to use tools, both traditional and modern, and that severely limits their future learning and therefore employability skills. The ability to construct, deconstruct and problem solve new products in the twenty-first century are dependent upon the ability to manipulate and use tool and materials established in primary school.

Certification

This Thesis is entirely the work of Alwyn Powell except where otherwise acknowledged. The work is original and has not previously been submitted for any other award, except where acknowledged.

Principal Supervisor: Professor Peter Albion

Associate Supervisor: Associate Professor Petrea Redmond

Student and supervisors signatures of endorsement are held at the University.

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United Nations Rights of the Child Article 29
Parties agree that the education of the child shall be directed to:
The development of the child's personality, talents, and mental and physical abilities to their fullest potential. UNICEF (1989, p. 5)

1 Introduction

The focus of this exploratory research study was to identify what tools, materials and adhesive methods children in Southern Queensland primary schools currently use and what influences impacted upon their use. The use of tools and materials has been identified as supporting the growth of the child's physical and cognitive skills including those identified as life and vocational skills and are used across all primary school curriculum areas. In twenty-first century Queensland, developing these general skills that transcend specific curriculum discipline areas is highlighted within the notion of UNESCO's (2016a) "transversal competencies" (p. 4). The use of tools and materials is also part of the Australian Curriculum focus on science, technology, arts and mathematical manipulative skills as highlighted in the design technologies aims, "manipulating a range of materials, systems, components, tools and equipment creatively, competently and safely" (Australian Curriculum Assessment and Reporting Authority, 2014e, p. Aims).

This chapter will highlight the focus of the study and how the researcher identified the research questions. The chapter focusses on the developing education of the whole child including physical development and fine motor control in manipulating tools. It highlights the significance of the use of tools, materials and adhesive methods and related concerns of safety and child development.

1.1 Focus of study

This study identifies the use of tools and materials and associated adhesive methods introduced over the primary school years with links to how children develop their physical skills to the fullest, including fine motor and manipulative skills. It aims to provide insights into how improved access to activities that promote fine motor and manipulative skills, as part of their development in educational general capabilities (Australian Curriculum Assessment and Reporting Authority, 2014b), can promote children's confidence, creativity, innovation and well-being. The thesis will start with a brief review of contemporary influences on the rights of the child to an education and what education means within an information rich society and what educational influences are deemed imperative for the future of society. The use of tools is mentioned at different levels of formal education, as well as early childhood and post formal schooling. It will track these influences in chronological order from international, national and state perspectives.

From birth, a child starts to engage with gripping and grasping within reach. Fine motor skills develop alongside proximal gross motor skills such as upper arm muscles. “Fine motor skills refers to the movement and control of small muscle groups including hands, wrists, fingers, feet and toes” (Early Childhood Education and Care, 2017, p. 17). Physical growth of the child develops in parallel and in conjunction with cognitive understanding. “Furthermore, motor and cognitive skills would appear to develop hand in hand, because the same mechanisms of the central nervous system are responsible for controlling both motor and cognitive skills in parallel” (Finnish National Board of Education, 2012a, p. 8).

Children continually grow and develop their skills and understanding in the years before foundation year of formal school and the students gain greater control of their manipulative muscles as they start to engage with real everyday tools. “Tactile information from the fingers is necessary to adjust the grip to the weight and friction of the object” (Henderson & Pehoski, 2006, p. 10) Early years curriculum documentation in Queensland refers to development of fine-motor within the section on health and physical education by stating, “Children build a sense of well-being by using and extending the fine motor skills when integrating movements and manipulating equipment, tools and objects” (Queensland Studies Authority, 2006, p. 57). Brown (1981) in linking perceptual-motor and music programmes, “concluded that an integrated program of physical education/music based on the concepts of Kodaly and Dalcroze for 15 children, ages 4 to 6 yr., led to significant improvement in their motor, auditory, and language aspects of perceptual-motor performance” (p. 157).

Further, the child should start to engage with actual tools that are part of everyday life such as knives and forks, and not just imitation toy plastic tools. Children are often taught the need for safety in the handling of everyday tools by family members, such as through controlled supervised introduction of knives to cut food items such as fruit where sharp knives are essential. As Cryer (1996) stated "use sharp paring knives with sturdy handles" (p. 187), when actively engaging young children. The year three and four band description of the Australian technologies curriculum states "as the child moves through primary school year levels these fine motor skills are continued to be developed… They do this through planning and awareness of the characteristics and properties of materials and the use of tools and equipment" (Australian Curriculum Assessment and Reporting Authority, 2018a band description, technologies).

Flinn and Patel (2016) suggested that in building structures the following tools may be appropriate, "scissors, hack saws, craft knives, metal ruler, bradawl, hand drill, pine, hammer, nails, and ties" (p. 47). The suggestion here is that there is a developmental continuum of fine motor skills from prep to year six that evolves with the specific addition of tools across year levels. However, even though primary school teachers believe in the importance of developing fine motor skills as part of general capabilities it is noted that there is not a specific section within the general capabilities of the Australian Curriculum reflecting the physical development of children. In common discussions with teachers it has been mentioned that fine motor skills and hand strength of children can lead to poor handwriting because of poor pencil control and that children struggle with hand-writing because of it.

There is a growing body of evidence to suggest that young children's fine and manipulative skills are an indicator for future cognitive success. "Toys that encourage fine motor skills have the added benefit of growing the brain, especially the parietal cortex" (The Toy Association STEM/STEAM Strategic Leadership Committee, 2018, p. 11). The playing with toys adds sensory information to their interpretation of an object as they manipulate it. "A child's development can be affected by how they process and use sensory information" (Western Australian Government, 2013a, p. 1). The Finnish National Board of Education (2012b) suggested that "the changes brought about by physical activity in brain structures and functions create additional possibilities for learning" (p. 8). Owen and McKinlay (1997) highlighted that "overall, there is strong evidence for a correlation between DSLDs (developmental speech and language disorders) and motor difficulties" (p. 324). This development of fine motor and manipulative skills progresses as the child grows and participates in every day activity using tools and materials and therefore regular practical activities that promote developing skills is important. Stewart, Rule, and Giordano (2007) stated that "children with physical or other impairments are likely to have difficulty with hand skills, which impacts on their engagement in manipulative activities as well as participation in daily life routines" (p. 874).

Red flags are raised within the health departments of various Australian states when children do not achieve certain manipulative skill competencies by a certain age. The Western Australian Government (2013c) raised warning signs if a child aged seven to eight years "has difficulty using scissors" (p. 5). Further warning signs raise concerns of children aged eleven to twelve years with regards to fine motor skills if the child "has difficulty with construction and fine manipulative work or easily gets tired when completing a fine motor or writing task" (Western Australian Government, 2013b, p. 4).

In high school and vocational education the Australian qualifications framework states "Skills are described in terms of the kinds and complexity of skills" (Australian Qualification Framework Council, 2013, p. 11). These skills range from creative cognitive skills to "technical skills involving dexterity and the use of methods, materials, tools and instruments" (Australian Qualification Framework Council, 2013, p. 11). Within level two of the qualifications framework, students in lower to upper secondary school, should able to "have basic cognitive, technical and communication skills to apply appropriate methods, tools, materials" (Australian Qualification Framework Council, 2013, p. 12). This knowledge and skill level will allow them to engage with set activities and identify basic problems. This standard is reflected in the European qualifications framework that relates skill development as having two sections cognitive and practical. "In the context of European Qualifications Framework (EQF), skills are described as cognitive (involving the use of logical, intuitive and creative thinking) and practical (involving manual dexterity and the use of methods, materials, tools and instruments)" (European Commission, 2015, p. Descriptors).

Some schools and researchers have suggested sample classroom tool kits as illustrated in the sample school/classroom tool kit, see Table 1, for primary school by Makiya (1992). Safety and usage of each of the tools listed including the saws and drills would have to be taught to the children

Table 1.

Sample Primary School Class Tool Kit suggested by Makiya (1992).

5 junior hacksaws and spare blades Metal safety rulers	1 hand drill, drill bits (3,4,5,6, and several 2mm) 3 try-squares	Craft knives 3 abraders 1 bradawl	5 Table vices 1 hammer Nylon cutting mats

Tools and manipulating materials are also mentioned across the curriculum disciplines in the Australian Curriculum (Australian Curriculum Assessment and Reporting Authority, 2018a). Examples include technologies in foundation year level stating "use materials, components, tools, equipment and techniques to safely make designed solutions" (ACTDEP007); to making models in mathematics, "make models of three-dimensional objects and describe key features" (ACMMG063), and in the arts "develop and apply techniques and processes when making their artworks" (ACAVAM115). One of the few specific mentions of fine motor skills in the Australian Curriculum is given in the Chinese language study curriculum with regard "developing fine motor skills appropriate to Chinese writing conventions" (ACLCHU138). Further examples of cross-curricula use of tools are listed in the Appendix One of this thesis.

1.1.1 Handwriting

The use of tools and the development of fine motor skills are inextricably linked. Handwriting is a good example of development of fine motor skills linked to a tool, such as a pencil. In Queensland, The Teaching of Handwriting- a handbook (Boys, 1984) highlighted the developmental nature of handwriting skills and the link to fine motor skills; "write with a combined finger/hand/arm movement" (p. 1). The individual child, with practice and instruction improves handwriting skills. "Factors such as kinesthesis, fine motor skills, and visual motor abilities are associated with handwriting development and performance" (Henderson & Pehoski, 2006, p. 238).

"When properly taught, handwriting enables students to more efficiently perform a hierarchy of skills required in other subjects" (Saperstein Associates, 2012, p. 6). Interestingly, "Handwriting legibility influences teacher's perceptions of students' academic competence. Thus, it is important that teachers (.…) help children develop adequate skills. Our findings reveal that practical, engaging activities focussing on fine motor skill development and practice do help" (Rule, 2002, p. 12). Feder and Majnemer (2007), further indicate the importance of fine motor skills in handwriting and identify some of the skills involved "Fine motor control, bilateral and visual–motor integration, motor planning, in-hand manipulation, proprioception, visual perception, sustained attention, and sensory awareness of the fingers" (p. 312).

Tools and materials are also linked where the tools are used to manipulate, deform, or cut materials. The coordination, control and strength needed of motor control including gross and fine motor is developed over time through the use of tools. "The tool becomes an extension of the hand. When one writes, one is not aware of the pen as a tool separate from the hand. Rather it is an integral part of the automatic movements that create the letters" (Henderson & Pehoski, 2006, p. 14). This understanding that tools become part of the extended hand is also reinforced by Baber (2006) who stated "Tools obviously modify the properties of effector systems, i.e., a hand holding a hammer differs in mass and posture to an unencumbered hand" (p. 3).

The development of increasing complexity of fine motor skills linked to the use of tools and materials can only be acquired through regular practice with a range of similar tools and materials, thus enabling the child to create and innovate with tools and emerging materials. As Henderson and Pehoski (2006) stated "The motor programmes are learned by practice when different information adjusts the ongoing movement" (p. 47). The concept of practice with the use of tools in differing situations including with different materials to develop skilled use in the use of tools is reinforced by Baber (2006) when "relating the possible actions to the perceptions of tool in the hand represents a form of perception-action coupling that needs to be learned and modified through continued exposure" (p. 6).

Therefore, the question remains, what tools and materials and adhesive methods are introduced and developed in each year level? Hence this study is about which tools, materials and adhesive methods are being used and when. That is the focus of this study.

1.2 Research Question

Competence and efficiency in the use of tools is not developed through a singular use of a tool with a material. Rather it is acquired through a combination of introducing tools and practising with those tools using a variety of materials over time. It has been reported that children "take pains to acquire deftness and skill" (Hadow, Harris, & Burt, 1931, p. 155). The time allocated ranges from supported very structured introduction focussing on safety and appropriate use with highly scaffolded learning with one on one and small group adult support, through increasing confidence of the child in the use of tools, materials and adhesives. The child then progresses to accept growing responsibility for their own use of the tools and materials. Students would be encouraged to explore new and creative modifications to the tools and the possible uses as they explore the use of tools whilst engaging with new materials and ideas. Primary school offers a critical timeframe in a person's lifetime for introducing basic and increasingly complex tools over a seven-year period from five to twelve years of age. This progression would indicate that there are tools, materials and adhesive methods accessed and introduced to the child as they develop in size and strength, cognition, desire to learn and become integral members of society.

This progression leads to the research question: What are the patterns of usage of tools, materials and adhesive methods currently provided by primary school teachers for students in their class to develop skills in the use of tools, materials and adhesive methods?

In seeking to answer the research question, five sub-questions have been identified:

1. What tools are currently being used in primary schools, and when are they introduced?
2. What materials are currently being used in primary schools, and when are they introduced?
3. What adhesive methods are currently being used in primary schools, and when are they introduced?
4. What skill development opportunities have teachers had in the use of tools, safety, materials and adhesive methods?
5. What factors influence the introduction and development of skills with tools, materials and adhesives in the classroom?

1.3 Definitions relating to the study

The participant teachers in this study come from different schools and education systems, as well as diverse life experiences. Therefore, to avoid ambiguity in the completion of the research participants need clarity in the meaning of similar terms. Defining the term as 'constitutively', as in a dictionary definition is suggested by Wallen (2001) who advised, "as researchers, we simply explain in other words what we mean by the term" (p. 16).

Adhesive methods	Adhesive is often used synonymously with glue. However, adhesion is about the amount of grip between two materials and the mechanism by which that grip is modified. For the purposes of this study, adhesive methods are the mechanism by which two or more materials are joined together and include glues, ties and fasteners such as nails and screws.
Ad hoc	Ad hoc (Ah) refers to the unplanned opportunities to use tools, materials and adhesives in the everyday activity of the classroom. For example, a child may use a rotary cutter to trim A4 pages, to enable the sheet to fit neatly into a scrap, science or history book using a glue stick. The use of the material, tool or adhesive is dependent on the situation as it occurs.
C2C	Curriculum into the classroom (C2C) is a resource package developed by the Queensland Education Department to support Queensland teachers in the implementation of the Australian Curriculum. Whilst written for Queensland Teachers it has spread across Australia to be used in Queensland, Northern Territory and Canberra education systems.

Developmental — Developmental (De) refers to the planned use of a tool, material or adhesive by a teacher, including discussion of its properties, instruction in skill development and time to practise. For example, a child may be asked or wish to cut out circles from 150 gsm card to be used as wheels. Here the discussion may include the weight of card measurement in grams per square metre (GSM) and how to hold and manipulate the materials to use a pair of scissors effectively and safely. Discussion may also include how to work towards a certain standard of completion. Whilst ‘developmental’ in different forms is hierarchical, in that it continually builds upon itself, it should not be taken to mean step by step or linear sequential. It is possible that teachers may introduce a tool in an instructional manner at the beginning of the year and then provide opportunities to use the tool in an ad hoc fashion once the teacher feels the children have mastered the tool.

Foundation year — In the Australian Curriculum the first year of formal schooling is called foundation year level.

MASTO — Materials, tools and adhesives are used across the curriculum areas but specifically mentioned in the curriculum areas of technologies, the arts, mathematics and science. It is possible to assume then that there will be opportunities for the students to be taught the skills necessary to work them effectively. They are also used in the other curriculum areas such as English, languages and humanities, though most likely in an ad hoc way. Therefore, to gain an understanding of where they are most used the participants will be asked to indicate if and where they use them in (M)- mathematics, (A) – the arts, (S)-science, (T) – technology, and (O) –other (MASTO).

Materials	Materials are those objects natural and manufactured that are the base ingredient for making products and include such items paper, card, fabric, wood and metal.
Preparatory year (Prep)	In Queensland the first year of formal compulsory education is called Prep, and it aligns with the Australian Curriculum foundation year level. Children start prep in the year they turn five by June 30^{th}.
Primary School	Primary school in Queensland starts in Prep and year one and moves through to year six. It is sometimes aligned to Elementary school in other countries. The age range of primary school children is from five years to twelve years old. Primary school education is compulsory for all children in Australia.
STEAM	Science, technology, engineering, arts and mathematics (STEAM) are recommended in by education systems in some countries, including South Korea, to build into STEM, creative and innovative understandings.
STEM	Science, technology, engineering and mathematics (STEM) are the key subject disciplines recommended for the skills in the twenty-first century.

Tools	Tools referred to in this study are those concrete hand-held instruments that assist with the shaping and remodelling of materials and include such items as scissors, hammers, hole punches and knives.

1.4 The researcher

As an experienced senior primary school teacher with thirty-five years classroom experience that included, over the course of that time, teaching each year level from preschool to year seven I was implicitly aware of the physical growth and capabilities of children. My role included positions of added responsibility comprising teacher in charge of preschool, teaching principal, Queensland State curriculum writer (Science), and Key learning area science regional co-ordinator.

These experiences also led to be involved with professional discipline organisations such as the Queensland History Teachers Association, Early Childhood Teachers association (ECTA), Mathematics Teachers Association of Queensland (MTAQ), and Science Teachers Association of Queensland (STAQ). Participation in these organisations included being President of the Science Teachers Association of Queensland and its representative on the Australian Science Teachers Association (ASTA).

As an active participant in these professional organisations, I conducted seminars and workshops for teachers, principals, parents and children. Some of these workshops were conducted in local, State, National and International conferences. A practical STEM workshop was Conducted in the STEM conference in Vancouver, Canada on automata for the primary classroom (2014). Most recently workshops for the Primary Mathematics Teacher Conference in Brisbane, Queensland (2018) and Primary Science Teachers Conference in Brisbane, Queensland (2018). I have written several practical papers associated with the workshops for primary school teachers that were published in association journals. These papers included making and using nets for constructing cubes in mathematics, automata models, and robots.

I was also able to attend training seminars and workshops on Primary Connections and Primary Investigations programmes, developed by the Australian Academy of Sciences in Canberra. Completion of these seminars led to becoming a qualified trainer to provide the professional development programmes for teachers. Constructivist theories of Piaget and Vygotsky underpinned both the' Primary Connections' and its predecessor 'Primary Investigations programmes' (Australian Academy Science, 2008).

1.5 Personal significance

Personal observations of the ability of children in a year five class to accurately measure, cut, fold and construct simple automata machines following explicit instructions using everyday curriculum tools and materials raised concerns leading to this investigation. Making and using tools and developing skills and expertise in a variety of tools is a lifelong trait of human beings. As children grow, they engage with tools in many situations from eating, engaging in the school activities making things, gardening and play. The tools and materials used often start with single use tool such as steak knives or taps for the garden hose, to multi-tools such as pencil and compass to draw rings, or to more specific tools such as Allen keys for constructing flat-pack furniture.

As an award-winning primary school teacher, including Queensland Smithsonian Design Fellowship and a Prime Ministers Prize for Excellence in Primary Science Teaching and with more than thirty years teaching experience from preschool to high-school, I have observed increasing numbers of children struggling with manipulating tools and materials efficiently and carefully. In 2011, when making flying toys for science, ten-year-old grade four children were observed struggling to problem solve how to measure and make the largest equilateral triangle from a given tissue rectangle, make the largest tissue square, and then glue with one-centimetre glue tabs to assemble a hot air balloon. To make water rockets that spiral and water rockets that release a parachute, children had to problem solve and construct neatly and accurately. Eleven and twelve-year-old children, from grade 5 and 6, struggled to measure accurately, estimate efficiently and problem solve for the best angle of attack into the wind and learning how and where to tie knots.

Prior to the introduction of the Australian Curriculum in 2014 in Australian schools, the use of tools in Queensland schools was extended and developed across all of the curricula including science, technology, mathematics, the arts and humanities. The disciplines of humanities in primary school commonly went under an integrated title such as 'social studies' (1960's) or 'studies of society and the environment' (2000), to more recently HASS (humanities and social sciences) encompassing disciplines such as geography and history. Under the auspices of the 1960 and 1970 Queensland social studies curriculum documents, children in primary school often made dioramas or models of important historical or geographical significance. These included using tools, adhesives and materials including papier mache, in the making and labelling of, mountain ranges and valleys, planetariums with models of the planets and sun showing phases of the moon, to building castles and moats, igloos, gunyahs and other houses. "make a model showing a miner's hut, his shaft and windlass, etc" (Department of Education Queensland, ND (circa 1960), p. 37). Models in science included body parts such as the workings of the eye and boats as "make a boat out of balsa or cork" (Queensland Department of Education, 1966, p. 23). In English and languages other than English puppets were constructed to assist in story-telling and in the arts, jewellery and sculpture were produced. Mathematics allowed the construction of three-dimensional shapes in geometry. Each of these developed and provided practice opportunities for specific tools of increasing complexity in conjunction with making products to aid in the learning process. "Little children may be allowed to discipline their fingers by making things in paper and cardboard" (Hadow et al., 1931, p. 79).

Throughout schooling and beyond, further specialist tools of trade became more important, more dangerous, and required increased safety measures. In the twentieth and twenty first century a new wave of technological tools to assist with providing the needs and wants of everyday life in cheaper, mass produced ways have emerged. These tools included production lines, robotics and three-dimensional printers, copiers, scanners, electrical tools and computers. Growing children needed the strength and knowledge to effectively engage with developmentally appropriate tools and materials.

New born babies do not have the strength, coordination and understanding to use tools such as scissors, hole punch, stapler or glue stick. Allen (2006) suggested in motor development a child up to four months has “insufficient strength to hold items” (p. 71). A year one child has not mastered the hand grip and control of using a pencil in handwriting of a legible own style or calligraphy script. Nor have they the coordination of both hands when using a ruler and pencil to rule a straight line. Yet, in primary school by year five, about ten years of age students “take great joy in perfecting handwriting skills” (Allen, 2006, p. 200). In primary school by year five, about ten years of age, according to the Australian and Queensland curriculum support documentation, children are expected to be able to safely choose and use effectively and efficiently tools such as box cutters, hole punches, staplers, fret saws, three ply wood, straw board, polyester-cotton, hand-drill, hot glue gun and ruler to name a few. These tools and materials are in the referenced supporting document photographs and not specifically labelled.

Based on the Australian Curriculum, children in middle primary school classes are expected to design, draw, construct and animate many objects related to the curriculum being taught, discussed and learnt, safely with growing precision and in a timely manner. There is expectation that by year five, ten year old students would have strength, persistence, skills and expertise in using scissors, cotton fabric, needles and polyvinyl acetate (PVA) glue; had some introduction to safely using Stanley knives, hot glue guns and be ready for introduction of such tools as soldering irons and 3D printers (Australian Curriculum Assessment and Reporting Authority, 2018d).

However, from personal observations whilst teaching years four, five, six and seven many children in upper primary school years demonstrated a lack of understanding of even the most basic tools and materials, including what they are for and how to use them safely. For example, in teaching design technology in a year five and six makerspace, students did not know what a hand drill was, comparing it to a fishing reel. The school makerspace was an area set aside within the school where children could engage in making objects from everyday resources with time set aside during school operating hours under the support and guidance of the teacher. The students complained often about their hands hurting and being tired when asked to complete a specific project; and were unaware of effective safety precautions; and saw no value in accurately following instructions to make a quality product.

Students in year one did not have the hand strength to use a six-millimetre single hand grip hole punch but were able to use lever operated two-hole desk punch. Year six students struggled to accurately position a single hole punch and punch through two pieces of one-hundred and fifty grams-per-square metre (GSM) photocopy card.

Similarly, year four children struggled to use a desk stapler to staple two pieces of card stock accurately not realising the crepitus (that is the sound of the staple felt separating from the row of staples and the second movement of the folding legs under) of the stapler pushing the staple through the card had two movements. The first movement felt through operating the stapler was of the staple releasing from the magazine and entering the material, followed by the second movement of the staple machine folding the legs of the staple.

In a year four and five history class using automata (mechanical models with moving parts), some students were asked by their teacher, ‘why have you placed the hoe blade upside down in the model?’ The response given was they ‘did not know what a hoe was, what it was used for, nor how the farmer used it; nor could they suggest possibilities from the shape such as cutting into the soil with the blade down or breaking up clods of dirt with the blade up’. Nevertheless, according to the Australian technologies curriculum (Australian Curriculum Assessment and Reporting Authority, 2014f) by the end of year four, students explain how products, services and environments are designed to best meet needs of communities and their environments.

From my recent experiences, children in all year levels demonstrate a lack of understanding in the use of scissors accurately, and on the school booklist a particular type of scissor was not defined, so children had a range of scissors to engage with.

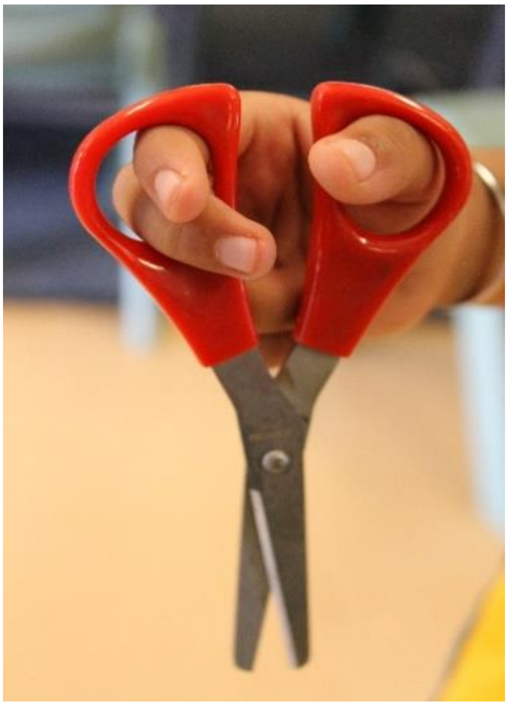

Figure 1. Scissor grip upside down.

Figure 2. Incorrect scissor grip waiting for scissors to do something.

In Prep or foundation year level students, four to five years of age have been observed holding scissors as in *Figure 1*, with the blades down and others as in *Figure 2* holding them with the blades in the right direction but waiting for something to happen with incorrect grip, two fingers in one hole.

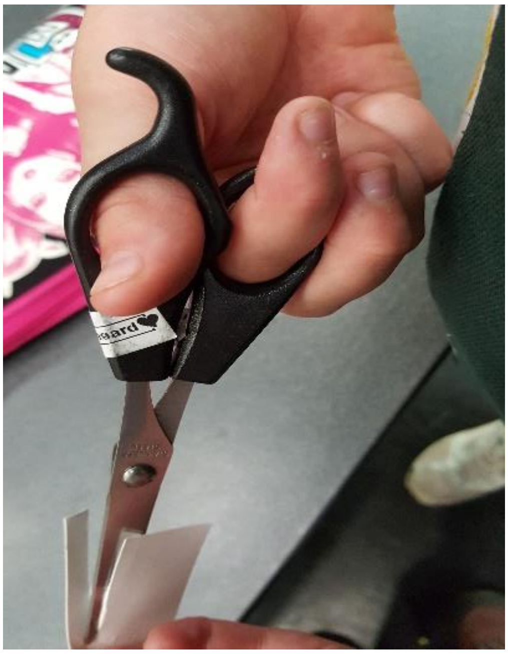

Figure 3. Scissor grip with hair trimming scissors.

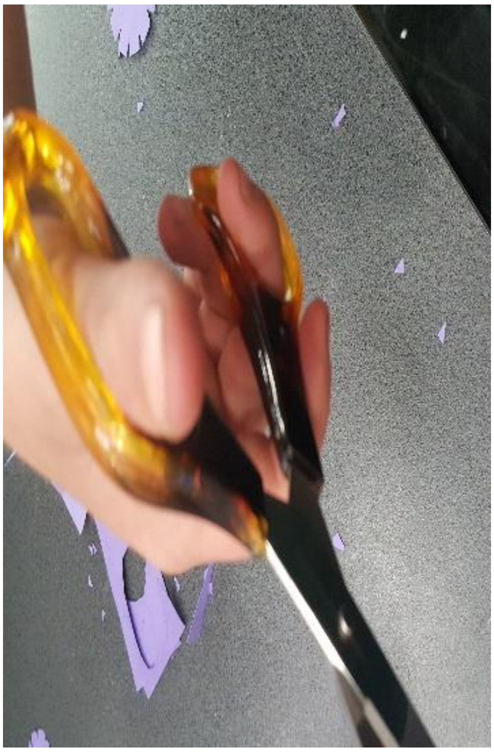

Figure 4. Scissor grip upside down.

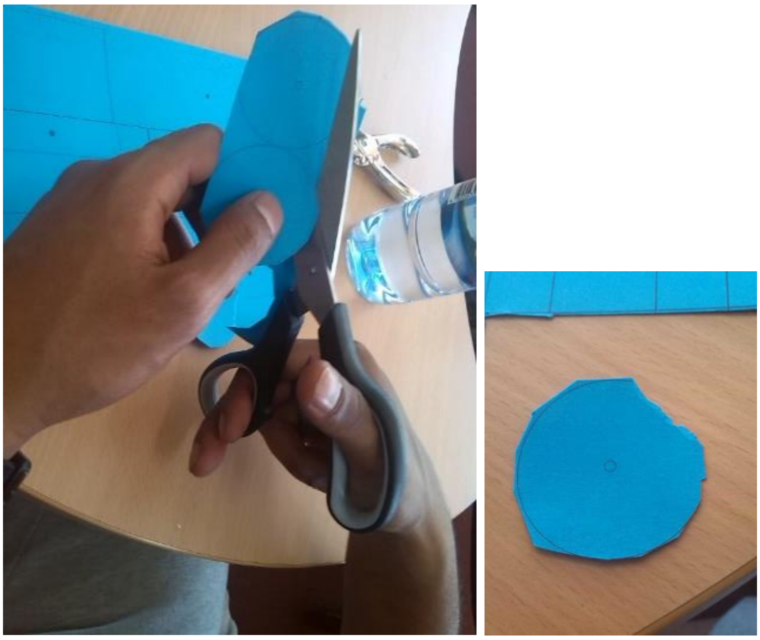

Figure 5. Adult using scissors upside down with resultant cut-out.

Children in middle and upper primary years (eight to twelve years of age) demonstrated incorrect ways of holding scissors. In the first image in this group, *Figure 3*, the student is using the thumb and the proximal phalange on the index finger, which limits control and strength, upside down. The second image, *Figure 4*, also shows a year six student using the scissors upside down, and the last image, *Figure 5*, shows a first-year university engineering student holding the scissors upside down struggling to cut accurately.

Safety concerns raised the most worries with students in year six unable to correctly wear safety goggles or use a box cutter safely.

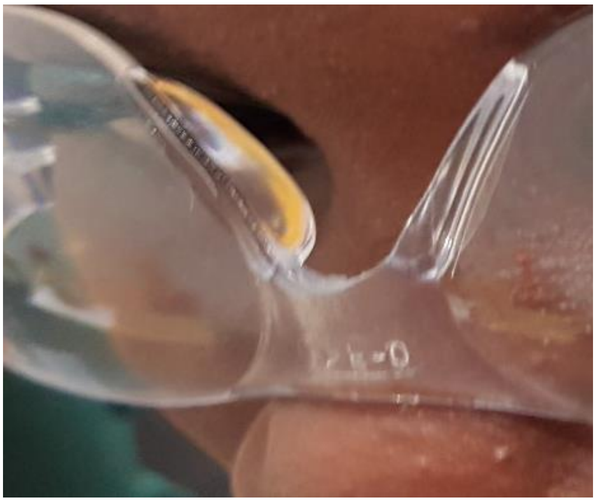

Figure 6. Safety goggles upside down.

The picture in *Figure 6* shows an upper primary school student wearing safety goggles upside down, as it was the first time the student had worn safety glasses.

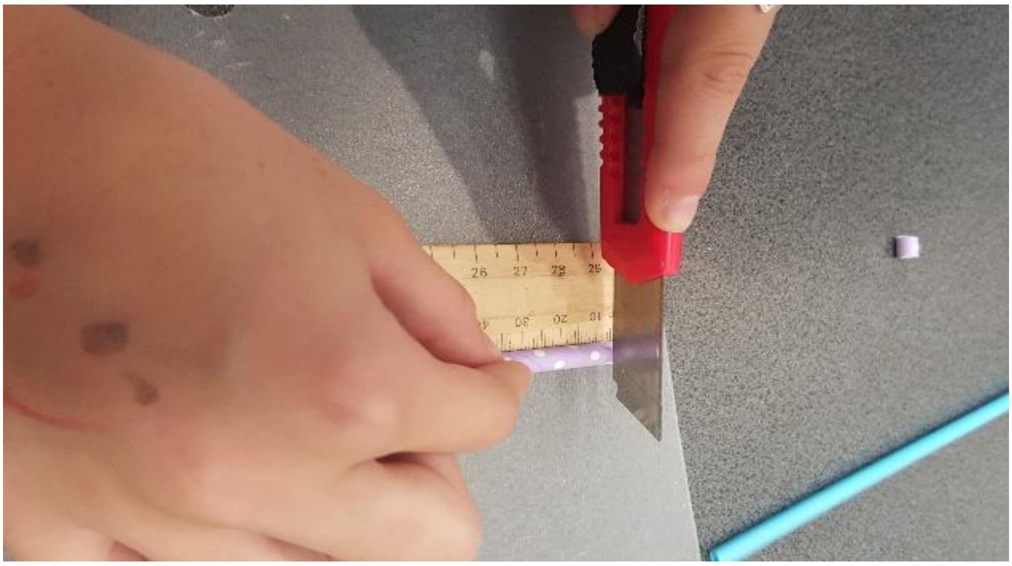

Figure 7. Box cutter upside down.

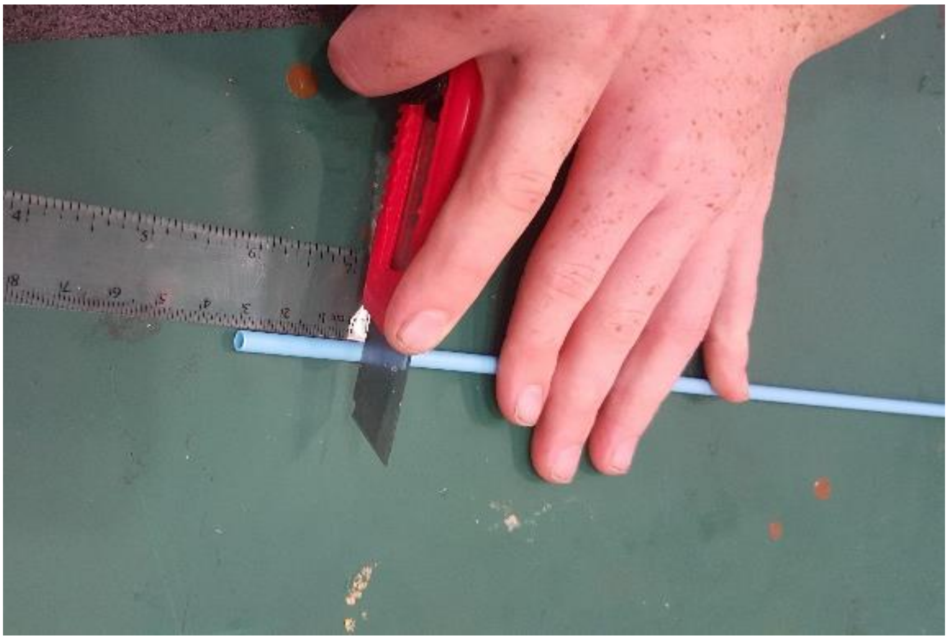

Figure 8. Trying to measure and cut accurately.

Similarly, in *Figure 7* and *Figure 8*, the year six students were using the box cutter but did not understand the mechanics of using a blade, including which side of the blade was the cutting side. The students were trying to measure accurately and carefully, though they did not measure and mark with a pencil.

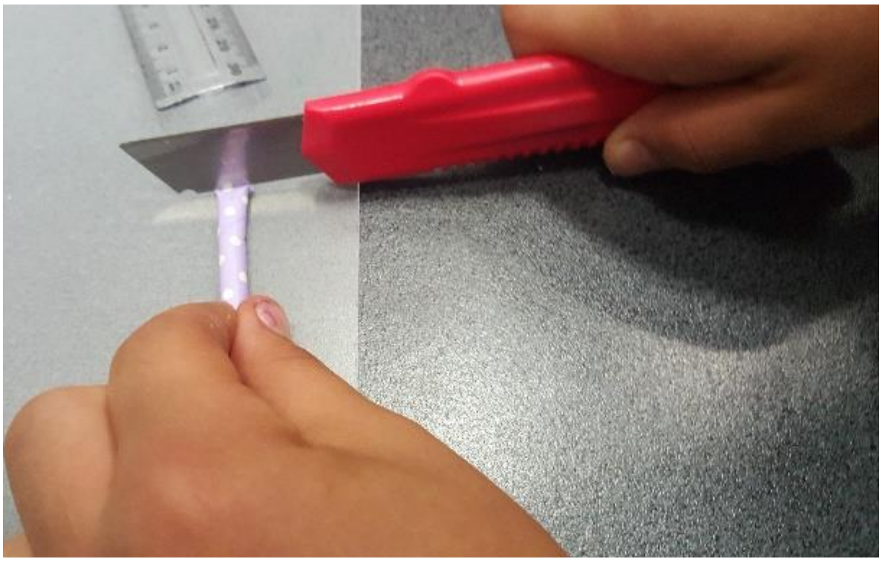

Figure 9. Not cutting paper straw.

In *Figure 9*, the student is cutting a paper straw and does not realise that, because the blade is upside down, they are squashing the straw rather than cutting it. The location of the hand on the knife also indicates a lack of effective control.

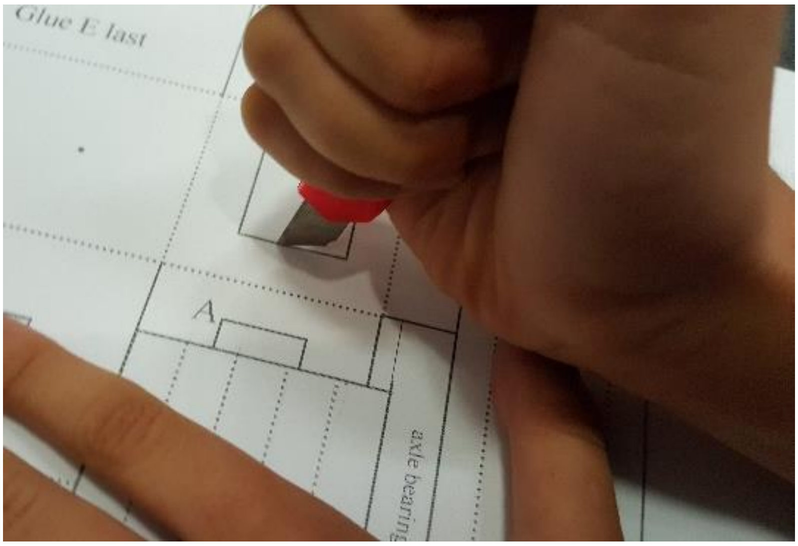

Figure 10. Fist grip.

The fist grip shown in Figure 10 indicates that the student will have difficulty with accuracy as it is difficult to view the blade point. Safety is of concern in the picture with the location of the thumb in holding the card being cut and the direction of the cutting blade.

Figure 11. Cutting horizontally by dragging blade sideways.

In *Figure 11*, the student is cutting the line by dragging the blade sideways, rather than orienting the blade to the required cutting direction correctly.This meant the card was gouged rather than cut. The hand grip for each of the students using the box cutters are different, with accuracy of control limited in each. The grip also shows the blade in the wrong configuration for cutting, when cutting towards the operator.

When using a skewer to score folding lines when using a fist grip, compared to a tri-pod pencil grip,the students invaribaly did not have the dexterity to control the amount of force applied and then tore or puncured the paper or card. The lack of dexterity in the use of these and other tools at a level expected from children in the upper primary school increases the time and resources required to effectively complete a given task safely.

The inability of children in my primary class to manipulate tools safely and effectively prompted me to explore why this may be the case. To try and identify what tools and materials teachers were introducing and using with their classes, and how they developed from the earliest year levels in primary school. With a view to suggest better ways to ensure that the children had opportunities to aquire the skills they deserve and need.

1.6 Significance of study

The development of fine motor skills and the use of tools is indicated as part of the four pillars of the UNESCO (1996) education framework, which could align most closely with the concept of general capabilities in the Australian Curriculum. General capabilities or life skills develop alongside cognitive skills in the child as they grow and learn. “In the Australian Curriculum, capability encompasses knowledge, skills, behaviours and dispositions. Students develop capability when they apply knowledge and skills confidently, effectively and appropriately in complex and changing circumstances, in their learning at school and in their lives outside school.” (Australian Curriculum Assessment and Reporting Authority, 2018e, p. Overview)

P Gerber, Wilks, and Erdie-Lalena (2010) further state, “like all developmental streams, fine motor milestones do not proceed in isolation but depend on other areas of development, including gross motor, cognitive, and visual perceptual skills” (p. 268). The developmental use of tools would then be expected to be found across all the discipline areas of the curriculum in primary school.

It is the development of the knowledge and skills in children that is the critical learning. The teacher provides experiences in the introduction, instruction, and opportunities to practise with tools and materials for the child learn and grow. Whilst tools in general are mentioned in different discipline curricula documents, at differing year levels in primary school there is no documentation of specific tools to be introduced, skills and expertise to be developed in conjunction with student’s physical maturity. Further, introduction and correct knowledge, safety, and skills for specific tools, materials and adhesives in the development of fine motor skills for both teachers and students is missing.

Somewhere along the continuum of developing fine motor skills and knowledge between prep year, where they are specifically mentioned as part of health and physical education and year six at the end of primary school, the continuing development in the use of tools to skilfully cut, bend, join and manipulate materials has become lost. Neither are they identified within the general capabilities section and the learning areas of the Australian Curriculum. This study highlights the lack of fine motor skill development as it relates tool use, the manipulation of materials and methods of adhesion within the primary school. Further, it identifies that the lack of instruction in tool use impacts upon the use of materials and adhesives that are identified in the Australian Curriculum, and that have been highlighted as important for the development of the whole child. The study also identified that fine motor skill development does not get a specific mention in the Australian Curriculum general capabilities nor in the science, mathematics, arts, or technology disciplines.

With the advent of a focus on Science, Technology, Engineering and Mathematics (STEM) as major cognitive areas for primary school curriculum the links between discipline knowledge and physical development of the child become increasingly important. Physical development of the child includes fine motor skills and associated gross motor skills. Fine motor skills are developed through use and practice of tools in the manipulation of materials to make a product. UNESCO (2001) referred to the skills of making of a product in basic education as life skills that encompass those skills referred to as vocational skills, loosely defined as those skills that have a practical application developed through hands-on learning especially in the years beyond primary school, related to those practical skills associated with specific occupations. Recent studies have identified the importance of life skills as associated with vocational skills and come under the banner of transversal competencies as highlighted in the UNESCO (2016b) transversal competencies in education policy and practice report .

In the making of a product the child progresses in control, competence and efficiency in the use of tools paralleling their development of fine motor and gross motor muscles. As well as physical development the use of tools can assist cognitive development of children in the STEM and with the addition of the arts curriculum STEAM (Science, Technology, Engineering, Arts and Mathematics).

1.7 Structure of thesis

This thesis has eleven chapters. As each of the sections developed, it was decided that each section had specific connected data to recommend each as a separate chapter. The body of the study is followed by appendices including curriculum links and sample survey questions and references.

Chapter one provides a brief discussion of the problem and highlights several key terms used in the study. It then elicits the research questions and identifies the problem and significance of the study. There is a reflection on recent personal experiences of children using tools before an explanation of the structure of the study.

Chapter two provides a broad and extensive literature review including exemplars of fine motor skill and links to cognitive development. There is also a review of national curriculum and international studies in the use of tools.

Chapter three identifies the methodology and ethical considerations for the study. It identifies the progress and reasons for a hand delivered survey and ethical permissions for Catholic and State school visitations and accessing interviews with practising primary school teachers.

The range of schools visited is outlined in Chapter four, which also describes the demographics of the study and provides an overview of the data collected with regards to the participants initial comments from the survey.

Chapters five, six and seven provide an overview of the broad areas of the study including tools, materials and adhesive methods, with commentary from the interviews conducted. Chapter five specifically focusses on tools, whilst chapter six focusses on materials and chapter seven on adhesive methods.

Chapter eight provides a small chapter on safety with regards to tools and materials mentioned. Chapter nine provides an in-depth analysis of selected tools, materials and adhesive methods. Chapter ten discusses the themes that developed out of the study.

Chapter eleven provides a conclusion and recommendations for future research. It identifies ten recommendations. The conclusion refers to the future of tool and materials usage and has links to STEM and STEAM.

1.8 Chapter summary

This introductory chapter has highlighted the significance of using tools, materials and adhesive methods in the primary school as having continuing relevance to children’s physical development including fine motor skills, and an adjunct to cognitive learning and for engaging children in developing efficient life-long skills. It has identified that whilst tools, materials and adhesives are mentioned in broad and generic terms across the curriculum there is no scope and sequence of when specific tools nor materials are introduced either by year levels or by bands of year levels. There is no identification of the development of fine motor skills in education curriculum within the primary school curriculum. This exploratory study was aimed at identifying what tools, materials and adhesive methods are introduced and used in the primary school, with a view to developing recommendations to support teachers in their implementation.

This study reflects my belief in the United Nations Convention on the Rights of the Child that states that the education of the child shall be directed to broad and holistic education. This broad education is critical in allowing for the fullest development of the child including their fine motor physical development, and is inclusive of accessing a wide range of tools, materials and adhesive methods. My own life experiences have benefited from being able to actively engage with tools and materials, both for employment opportunities and recreation. My observations of children, reflected in this study, indicate that they are not being given the same opportunities to engage with and develop these skills and knowledge. My concerns are linked to how I can assist the learning of children to gain these skills through supporting of the primary school teacher.

The next chapter, chapter two, will present a scan of the relevant literature. The subsections in the chapter will identify the reasons for a broad education including the rights of the child, curriculum requirements, and physical development. This will be followed by identifying tools used in primary schools.

This literature review will assist in identifying a gap in the research in the actual implementation of curriculum in the use of tools, materials and adhesive methods. The literature review will assist in the development of the survey for the data collection.

2 Literature Review

2.1 Introduction

Children grow and learn from birth. The growth of children encompasses the aspects of physical and cognitive growth, first within the family and then with support of the community and then through more formal aspects of schooling. Families provide support for the child to engage with the fundamentals of movement, language and learning. Opportunities to grasp and crawl allow for the brain and body to coordinate and make networks whilst gaining strength. “Haptic perception emerges in early infancy and continues to mature into adolescence” (Henderson & Pehoski, 2006, p. 82)

Safe and stimulating environments include providing opportunities to engage with objects first to learn the objects properties, then move and manipulate the objects. Initially many of these objects are toys and are engaged within play. Next, as the child’s curiosity is enhanced and their creativity in the use of objects becomes more sophisticated, they start using tools to manipulate the objects around them, at the same time developing coordination of their muscle groups with their senses. Initially these attempts to modify objects may be seen in the use of simple tools to capture and cut food to feed. Safe use of metal cutlery and crockery is learnt, progressing to assisting cutting fruit and vegetables, and instruction on what to do when accidents occur. Then they progress to using coordinated efforts to get objects such as pencils and crayons to make marks on other materials. All of these efforts are supported, encouraged and affirmed by family and close community members.

Progressing to group education settings such as childcare and kindergarten allows for many social opportunities for increasing strength and purpose of learning, engaging with differing understanding and range of materials. The continuing development of children progresses to formal school, as part of their rights, where cognition is further developed along with the continuing growth of gross motor and fine motor skills as part of a wholistic education, with access to current technologies, tools, and expertise.

2.2 Right to an education

Education is a right afforded to all children according to Article twenty-six of the United Nations Declaration of Human Rights as promulgated in 1948 and to which Australia is a signatory. Points one and two of Article twenty-six in the declaration state;

1. Everyone has the right to education. Education shall be free, at least in the elementary and fundamental stages. Elementary education shall be compulsory.
2. Education shall be directed to the full development of the human personality and to the strengthening of respect for human rights and fundamental freedoms. (United Nations General Assembly, 1948, p. 34)

2.3 Defining Education

The United Nations Declaration of the Rights of the Child further explored and defined what constituted elementary education. It provided a framework for countries to develop an education system that enabled the articles to be met, especially Article twenty-nine which states; "parties agree that the education of the child shall be directed to: The development of the child's personality, talents, and mental and physical abilities to their fullest potential" (UNICEF, 1989, p. Article 29).

Following on from the declaration on human rights, the United Nations organised and held several meetings and conferences to tease out roles of the human population in developing and sustaining planet Earth, starting in 1972 with the United Nations Conference on the Human Environment in Stockholm. This meeting produced the Stockholm Declaration which proclaimed "conversely, through fuller knowledge and wiser action, we can achieve for ourselves and our posterity a better life in an environment more in keeping with human needs and hopes" (Stockholm, 1972, p. 3). Principle nineteen of the declaration highlighted the need for education. Following these meetings and conferences, discussion papers were produced on courses of action, all highlighting the importance of education.

Of special significance for education were the international conferences organised by the United Nations Educational, Scientific and Cultural Organization

(UNESCO) including those held in Tbilisi in 1977, Jomtien in 1990, Toronto in 1992 and Istanbul in 1993.

Australian State, Territory and Commonwealth Ministers of Education, accepting the responsibilities of the treaties outlined above, the met in Hobart and, conscious “that the schooling of Australia’s children is the foundation on which to build our future as a nation” (Australian Education Council, 1989). The Hobart Declaration on Schooling was created (Australian Education Council, 1989). Australia followed up its commitment to the obligations of the international declarations by ratifying the Children’s Rights Charter in December 1990. This means that Australia has a duty to ensure that all children in Australia enjoy the rights set out in the treaty.

Australia renewed its commitment to the *Rights of the Child* in Adelaide in 1999 with the publication of The Adelaide Declaration on national goals for schooling in the twenty–first century (Education Council, 2014), which reaffirmed the commitment to and importance of education in Australia. These declarations were then built upon, refined and superseded by the Melbourne Declaration on Educational Goals for Young Australians (Ministerial Council on Education Employment Training and Youth Affairs, 2008). Based upon the goals of the Jontiem conference (1990), the Australian States individually and simultaneously worked on frameworks that reinforced the commitment to education for the twenty-first century.

The World Conference on Education for All, Jomtien 1990, proceeded to develop further an understanding of basic education with the Declaration on Education, which highlighted, “Learning begins at birth. This calls for early childhood care and initial education” (UNESCO, 1990). The ‘Learning, the treasure within’ report to the UNESCO built upon these previous meetings and conferences highlighting four pillars of learning upon which education stands; learning to know, learning to do, learning to live together and learning to be (UNESCO, 1996). The United Nations Educational, Scientific and Cultural Organization conference in Thessalonica in 1997 further added discussion focussed heavily on sustainability and the role of education.

Learning to know focuses on the knowledge needed for both general understanding but also specific knowledge and understanding related to tasks and required for lifelong learning. Learning to do relates strongly to gaining useful employment and is broadened to encompass those social skills required to work in teams and deal with complex situations and may include higher education. Learning to live together recognises the importance of the interdependent nature of living in the twenty first century. Learning to be focuses more so on the individual and the importance of developing their capacity to the fullest including understanding of their rights and responsibilities.

The Dakar Framework for Action reaffirmed the importance of the education for all vision, indicating that, “education for all must encompass not only primary education, but also early childhood education, literacy and life-skills programmes” (UNESCO, 2000, p. 13). It goes further to state that

> Approaches to improving the quality of education require adoption of curriculum content and processes that are learner centred, recognize the diversity of learning needs and stages of cognitive, social and emotional development, and develop knowledge, skills, and attitudes required for independent learning and problem-solving. Improving the quality of education also requires access to appropriate learning resources. (UNESCO, 2000, p. 59)

A common definition of what constitutes a ‘Basic Education’ was still being developed in 2007, where the latest information referred to indicated that ‘fundamental, and ‘elementary’ education have become replaced by ‘basic education’ which more accurately reflects a foundation for lifelong learning. Primary education or “elementary education’ is now considered to be part of ‘basic education’ which is intended to meet “basic learning needs” (UNESCO, 2007b, p. 17).

Basic education needs are built upon the four pillars of learning. ‘Learning to be’, is one of the four pillars of learning and is of specific interest for this study as it points out that education is broader than economic requirements. “In that connection, education must not disregard any aspect of a person’s potential: memory, reasoning, aesthetic sense, physical capacities and communication skills” (UNESCO, 2000, p. 37). Hansen, Kaschefi-Haude, Samuelsson, and Jensen (2009) reflect on the importance of children developing all their capabilities in transitioning between different stages of learning and schooling in the European Union, as an important understanding of the rights of the child.

Education for Sustainable Development (UNESCO, 2005) adds further to the pillars of learning by reinforcing the concept of sustainability with the five pillars of sustainable development. The pillars supported the work of preparing the early years framework by Sumsion and Cheeseman (2009). Siraj-Blatchford, Smith, and Samuelsson (2010) further built upon with these pillars with the publication of *Education for sustainable development in the early years* which provided exemplars of what sustainability could mean in early years of a child's life including primary school. For example, "children are often given the opportunity of making things from old boxes, food and drinks containers and other 'recycled' materials. In some early years settings children work with more resistant materials, shaping and joining wood to make things" (Siraj-Blatchford et al., 2010, p. 23).

2.4 Early Years Curriculum in Australia

Accepting that 'basic education' starts at birth Australian states engaged in the development of early years frame works that would enable seamless progression from birth and into life-long learning. The State of Victoria developed its 'Early Years Learning and Development Framework For all Children from Birth to Eight Years' with a discussion paper in 2008 and published in 2009 (Victorian Curriculum and Assessment Authority, 2009).

Queensland developed its Early Years Curriculum in 2006 reflecting the four pillars of learning. It was designed to assist teachers with the introduction of a preparatory year into Queensland schools, which was replacing the preschool year. It was designed to "promote continuities through the preparatory year" (Queensland Studies Authority, 2006, p. 2). Because it reflected the four pillars of learning, its focus was upon continuity of learning and developed a framework that had five key organisers; early learning areas, contexts for learning, interactive processes for curriculum decision making, key components, and phases that describe children's learning and development. There were five learning areas within the early learning areas framework; social and personal, health and physical, language learning and communication, early mathematical understandings, and active learning processes (Queensland Studies Authority, 2006).

The health and physical learning area focus is on health and gross and fine motor development as children actively learn skills whilst interacting with others and their environment. “children build a sense of wellbeing by using and extending fine-motor skills when integrating movements and manipulating equipment, tools and objects” and this is further elucidated as entailing the use of, “familiar equipment, materials, tools and objects with increasing coordination, strength and control” (Queensland Studies Authority, 2006, p. 66).

The understanding of child physical development was built upon and reflected the importance of early education by the Australian government when Belonging, Being and Becoming (Council of Australian Governments) was published in 2009. The elements of the Early Years Learning Framework encapsulated learning outcomes, principles and practice. Learning outcomes were designed to enable children to develop their capabilities and knowledge of these elements; their identity and world, their wellbeing, and becoming confident, involved learners and effective communicators.

Children develop dispositions such as curiosity, cooperation, confidence, creativity, commitment, enthusiasm, persistence, imagination and reflexivity, and skills of problem solving, enquiry, experimentation, hypothesising, researching and investigating, when they are confident and involved learners (Council of Australian Governments, 2009). This is evident for example “when children explore the purpose and function of a range of tools, media, sounds and graphics” (Council of Australian Governments, 2009, p. 37).

The Queensland Early Years Curriculum Guide explicitly tries to link the early learning areas with the main learning areas of the Australian Curriculum but note that “while the content of these areas is described separately, most learning experiences integrate many or all of the five early learning areas”(Queensland Studies Authority, 2006, p. 52). For example, thinking, investigating, and imagining and responding relate closely to the key learning areas of science, studies of society and the environment, technology and the arts, through active learning processes, while fine and gross motor skills align with health and physical education. The revised edition of the Victorian Early Years Framework(2016b) indicated that “when provided with many opportunities and a rich supply of natural and manufactured materials and tools, children create, build, sculpt, draw, paint and construct, and they enjoy taking part in sustained shared conversations focused on their interests” (p. 21).

2.5 Australian Curriculum

The Australian Curriculum aspires to provide contemporary guidelines for the education of all Australian children to prepare them for their futures.

> In the 21st century, Australia’s capacity to provide a high quality of life for all will depend on the ability to compete in the global economy on knowledge and innovation. Education equips young people with the knowledge, understanding, skills and values to take advantage of opportunity and to face the challenges of this era with confidence. (Ministerial Council on Education Employment Training and Youth Affairs, 2008, p. 4)

Life in twenty-first century Australia is vastly different from the twentieth century due to technological advances based upon changing science and mathematical understandings. In the last fifty years the technological growth of computing power and design improvements have seen personal computers, smart phones and the internet become an integral part of our everyday life. New materials such as graphene and a range of plastics provide extra avenues for creative development. The new and developing tools, such as three-dimensional printers, laser cutters, interactive whiteboards and tablet computers (which use digital technology), have a major impact on society and the way we teach the young. Access to knowledge is easier and the quantity of information has increased dramatically. This increase will impact on employment opportunities leading Yates and Collins (2010) to suggest “that globalisation, particularly the globalisation of capital, and the growth of ICT as the major medium through which work and other communication happen, has revolutionised the economic world in which young people will have to find work” (p. 94).

The increase in utilitarian understandings of the role of education for the economic good of society is reflected within the foreword of the Organisation for Economic Co-operation and Development (OECD) report, on the 2012 the

Programme for International Student Assessment (PISA) results, “equipping citizens with the skills necessary to achieve their full potential, to participate in an increasingly interconnected global economy, and ultimately convert better jobs into better lives is a central preoccupation of policy makers around the world” (OECD, 2013b, p. 3). The importance of education is also referred to in the Review of the Australian Curriculum when indicating “the primary purpose of education is to enable students to gain a living by completing a certificate or qualification – whether professional or trade – that allows them to enter the workforce or to begin a career” (Wiltshire & Donnelly, 2014, p. 19).

Building on Australia’s commitment to educating all children and recognising the broad aspects of education, the Australian Curriculum developed a three-dimensional model that had three visible faces. The first face had eight learning areas, the second had three cross curriculum priorities and the third face seven general capabilities. The curriculum used this model to demonstrate how all the learnings melded together as shown in *Figure 12*.

Figure 12. Australian Curriculum model.
(Australian Curriculum Assessment and Reporting Authority, 2018a, pp., pp. f-10-curriculum/structure)

There has been a focus on the knowledge that all children in the compulsory years of schooling, including primary years, need to aquire, in preparation for their future employability. International and National efforts have been made to collate the specific knowledges into manageble groupings of like disciplines called learning areas, though not necessarily with consensus. Australia opted for eight learning ares combining similar disciplines; Science for example is an umbrella group for geology, biology, chemistry, physics, astronomy, and more recently environmental science. The Arts encompassed broad areas including media, visual arts, music, dance and drama. Interestingly in earlier versions of Queensland primary school syllabuses dance was part of the health and physical education, and drama was part of the English syllabus (Queensland Department of Education, 1968). According to Yates and Collins (2010), "to divide the content knowledges of the curriculum into these eight parts and organise them in a common way was a political/bureaucratic resolution to the problem of how State differences ofcurriculum substance and subject naming might be brought together" (p. 91).

In the Australian Curriculum these eight are; English, language other than English (LOTE), science, mathematics, health and physical education (HPE), humanities and social sciences (HASS), technologies, and the arts (Australian Curriculum Assessment and Reporting Authority, 2014b). Similar curriculum content knowledge and discipline groupings and labels are found worldwide; for example, as in Finland (Finnish National Agency for Education, 2014), Hong Kong (Curriculum Development Institute, 2017) and Scotland (Education Scotland, 2012).

English and languages, along with affordances of modern information and communication technologies provide students expanded opportunities to collaborate and communicate in interesting dilemmas across the world. Humanities and social studies provide contexts to engage with issues of the future including sustainability. The eight learning areas provide the basis for a broad education though within the curriculum listings are those subject disciplines with which it has been suggested children will need to have increasing access and success.

2.6 STEM and STEAM

To achieve in predicted future employment, those subjects that most align with twenty first century disciplines are those that encourage creativity, innovation and deep thinking are science, mathematics, engineering and technology (SMET). The acronym was changed to STEM to make it sound less like smut (T. Fox, 2018).Other combinations of the acronym abound and some were focussed on particular groups requirements such as MATES (maths and technology, engineering, science; a boys after school technology club), GEMS (girls) and ESTEAM (adding Entrepreneurship to the beginning of the acronym (Laming, 2017, p. 34). Further efforts to engage students in skills for the twenty-first century included the addition of arts to the acronym to encourage more creative and innovative thinking moving to the acronym STEAM, (science, technology, engineering, the arts, and mathematics) (Hunkoog Jho, 2014).

Whilst science, technology, engineering and mathematics are separate disciplines with specific knowledges and literacies associated with each, they are also related in suggested pedagogies including hands-on, active inquiry-based learning. Further, according to Willox (2012) these similarities should allow for integrated studies that are engaging, and develop student’s curiosity and allow for innovation.

The foundation skills, understandings and knowledge required in STEM and STEAM subjects are not always apparent, including vocabulary, manipulative skills, prior knowledge and concepts. Sometimes this led to structures that negated integrated curriculum opportunities to instil curiosity and interest in STEM subjects. Taylor (2016) highlighted the importance of adding the arts to enrich STEM, and when taught by innovative teachers it provides engaging and transformative learning. When discussing the developmental nature of measurement within general capabilities across curriculum First Steps in Mathematics (Department of Education Western Australia, 2013a) stated “if teachers were to wait until the middle years to start teaching about uniform units, then it is unlikely that students would develop all the necessary concepts and skills in one year” (p. 34).

In 2007 The Department of Education, Training and the Arts, Queensland published a forward looking discussion paper for STEM (Department of Education Training and the Arts, 2007). It stated that “the role of science, technology, engineering and maths cannot be underestimated (sic) in preparing Queenslanders for the challenges of the future. Innovation is key to economic growth and STEM is a key driver of innovation” (Department of Education Training and the Arts, 2007, p. v). This was iterated by the Australian Chief Scientist when he stated “ science and innovation are recognised internationally as key to boosting productivity, creating more and better jobs, enhancing competitiveness and growing an economy” (Head, 2014, p. 7).

The traditional content and focus of STEM subjects to provide the individual skills for the workforce and individual wealth of the person has shifted, most recently with a focus towards providing lifelong education as a function of economic prosperity of the nation. “Learning for the work place focuses on the skills required to earn a living and to adapt to changing economic and technological conditions” (Inter-Agency Commission, 1990, p. 63). A realization that the jobs people do in their life times are likely to change, as technology and knowledge change, therefore requires an education that is flexible and relevant to the individual to enable them to continue to learn throughout their lives. The economic need to maintain and develop the nation’s standard of living and indeed the whole world has focussed on what that might mean for employment skills now and in the future, with most recent reports proposing the need for creative and innovative thinkers. Rasinen et al. (2009)

suggested that “through technology education they learn to think and intervene creatively to improve the quality of life” (p. 34).

2.7 Cross curricula priorities

The three cross-curriculum priorities outlined within the Australian Curriculum align strongly with the importance of culture and sustainability, as outlined in the various United Nations declarations. The three cross curriculum priorities are Aboriginal and Torres Strait Islander Histories and Cultures, Asia and Australia’s engagement with Asia, and Sustainability. “Cross-curriculum priorities are only addressed through learning areas and do not constitute curriculum on their own, as they do not exist outside of learning areas” (Australian Curriculum Assessment and Reporting Authority, 2018a).

Increasing sustainability for future generations is gaining in importance and the future of the world is reflected in discussions on problem solving. The challenge for current students is to pose possible answers to major problems such as global warming, fresh water and health. However, there is little in the research that indicates a scope or sequence of how to introduce or broach these world problems to young children in prep or primary school. Similarly, “there is also little evidence that an early start in school compensates children for lower achievement that may be associated with deficiencies in their home learning environment” (Sharp, 2002, p. 16). Cotton (2018) indicated that providing children the opportunity to learn to take responsibility for their own learning would allow them “to learn a skill that they can take with them into primary classrooms and beyond” (p67).

2.8 General capabilities

The third face of the three-dimensional model for Australian Curriculum represents General Capabilities, which reflect the commitment to the international declarations that focus on the four pillars of learning: learning to know, learning to do, learning to live together and learning to be. “Along with a growing number of countries internationally, Australia includes capabilities in the core national documents governing education” (Lucas & Smith, 2018, p. 2).

Students today need a different range of skills as well as knowledge to develop competitive skills in the workforce. Innovation is critical, and “Australian industry needs to invest in innovation across all domestic and exporting sectors as one of the several key strategies to lift long term total factor productivity and ultimately maintain our high standard of living” (Office of the Chief Economist, 2014). This is iterated by the Australian Industry Group which states that “STEM skills are essential for the future economic and social well-being for the nation” (Willox, 2012, p. 1).

Skills for the twenty-first century including a focus on creativity, critical thinking, communication and collaboration are essential to prepare students for the future (P21, 2015, p. 3). “School leavers will need skills that are not easily replicated by machines, such as problem-solving, interactive and social skills, and critical and creative thinking” (Gonski, 2018, p. viii). The Queensland government went to the people of the State and asked what they thought was important in educating for the future and identified several points including, “developing diverse skills, such as creative thinking, critical reasoning and entrepreneurial skills and science, technology, engineering and mathematics (STEM)” (Department of Education and Training, 2016a, p. 4). Wigner (2017) indicated that the skills needed would cause a change in the education systems due to the changing technological environment.

Also listed often in discussions of skills for the twenty first century, are those personal attributes that include persistence, resilience and empathy leading to being confident and active members of society (Council of Australian Governments, 2009; P21, 2015). Children begin in the early years of schooling to develop their innate curiosity about the world around them and explore and learn through trial and error, and, when given the opportunity relate these to science and maths concepts (Laming, 2017; McDonald, 2015).

2.9 Learning areas

Curriculum support documents (Queensland Studies Authority, 2011) provide recommended minimum time allocations for each curriculum discipline and for each of the school year levels. The recommended time allocations were elaborated by the Queensland Department of Education in 2018, with the suggestion that “some learning areas and/or subjects can be implemented over time across a band of years, or compressed and implemented in a particular year in a band” (Department of Education, 2018, p. 1). For example, the design technology subject in band prep to year two could be compressed to be done in semester two year two, effectively meaning that for two and a half years of an elementary school child's life, it would be possible not to engage with tools, materials and adhesive methods. These suggested times change over the years as the child develops and the discipline knowledges become more specific.

In early primary school years developing language skills of speaking and listening, reading and writing play a crucial role especially in preparation for standardised testing and hence require a significant amount of available time. The production of quality physical artefacts related to the development of fine motor skills is deemed less important, as shown by the lack of a developmental scope and sequence of fine motor in the Australian Curriculum (Australian Curriculum Assessment and Reporting Authority, 2018a). The development of language in the form of vocabulary for recognition of everyday tool and material objects forms the foundation for those future disciplines of science, technology, arts and mathematics, but teachers also indicate a need to develop the skills and understandings associated with manipulating those objects (Reys et al., 2017, p. 32). Play and manipulating objects, discussing, labelling and exploring are important foundation skills that engage students, provide opportunity to develop self-esteem and self-confidence and continue the development of their literacy and numeracy skills whilst broadening their spoken vocabulary and interests. The early years are also important in the daily exploration of the properties of the material world around them by exploring, manipulating, discussing items with parents and teachers learn the foundations of problem solving, innovation and creativity. Through arts and craft activities young children further explore other avenues of communication and collaboration and with instruction develop skills with "crafts so that their self-esteem grows on that basis and they derive joy and satisfaction from their work" (Finnish Government, 2004, p. 240). Discussion from the early years research invariably reinforces the importance of child growth in terms of development of language, confidence, and physical skills, through active and involved learning of their world (Council of Australian Governments, 2009; Craft, 2002).

The active participation in building and playing with manipulatives can aid with developing positive attitudes to science, technology, engineering and mathematical subjects. McDonald (2015) stated that "engaging students in engineering activities that are fun, hands-on and linked to everyday contexts improves students' attitudes towards STEM subjects" (p. 17). Perry and Dockett (2002) highlighted play and its importance developing 'big ideas' in mathematics and risk taking with children. Other researchers echo the importance of early years exploring and playing as foundations for future STEM and STEAM success (Cameron et al., 2012; McLachlan, 2013; Thornton, 2009).

Active participation, engagement, play with manipulatives suggests engaging with physical materials in the development of children's skills and knowledge. To manipulate, construct, change and distort materials requires the use of tools, and in the use of physical world materials tools include hands-on physical tools. To join these materials adhesive methods are required, yet there is a gap in the research that indicates what specifically tools are introduced to primary children.

In Queensland, the Education department noted that one way to develop knowledge of tools and materials and integrate skills was through the worldwide phenomenon of Makerspaces. According to Peppler and Bender (2013) "the maker movement is an innovative way to reimage education" (p. 23). Makerspaces provide the opportunity for children to integrate STEAM knowledge in the creation of new products through the manipulation of materials and using tools, with many educators highlighting "the importance developing knowledge and skills in other disciples such as English, history and the arts" (Clapp, 2017, p. 38). Considerations of how to implement maker spaces into education include in-class time, school break time such as lunch and afternoon times, and out of normal school times.

2.10 Comparing education results

Whilst Australia has a high standard of living and achieves higher than average scores in international tests such as PISA and Trends in International Mathematics and science Study (TIMSS), concerns are being flagged that we are not improving along with the rest of the world. "Australia's PISA results have not improved since 2000" (OECD, 2013a, p. 5). This stagnation is reflected in the Queensland report 'A shared challenge: Improving literacy, numeracy and science learning in Queensland primary schools' (Masters, 2009), the Wiltshire review of Australian Curriculum (Wiltshire & Donnelly, 2014), and in the comment that the "average performance of Year 9 students on NAPLAN has remained relatively stable" (Masters, 2017, p. 1). Australian primary school student's achievements in the year four TIMMS international science tests have also fallen, with mean scores of 527 in 2007 falling to 516 in 2011, and comparative ranking dropping eleven places to twenty-fourth of fifty countries (Hackling, 2014).

Results of these studies may be in part due to the narrow focus on curriculum content and neglect of the integrative nature of the underlying skills and concepts that children engage with as they grow. Lockman (2000) presented a study that identified the affordances of tool use in child development especially from birth. He suggested that banging spoons may lead to hammering. Further that “tool use development may entail a more continuous and gradual process of discovery and exploration, not entirely dependent on some newly emerging form of relational or representational reasoning” (Lockman, 2000, p. 138).

The importance of the use of tools, materials and adhesives in the twenty first century primary classroom in the digital age is open to question. There are suggestions that even the manipulating of the most fundamental of tools, the humble pencil in the development of handwriting, is not needed. “Handwriting is dead, long live keyboard skills!” wrote Adoniou (2015) in a newspaper response to a report that Finland will cease compulsory cursive writing lessons. Similarly, with the advent of computer assisted design it has been suggested students no longer need to physically construct three dimensional shapes in mathematics, but rather can view them rotating on interactive whiteboards or using computer assisted drawing (CAD) to three D print them. “Tinkercad is a free, easy-to-use app for 3D design, electronics, and coding” ("Tinkercad," 2018).

The way Australians conduct education has changed as we moved from a state-based and generated curriculum system to a focus on a state interpretation of a national curriculum. The national curriculum built upon the Australian governments responsibilities as a signatory to the United Nations Declaration of Human Rights and the UNESCO Rights of the Child (UNESCO, 2000), to develop a curriculum that embraced a broad education.

Education for life goes beyond basic education and formal education, it more broadly refers to the need for humanity to continually engage in the process of lifelong learning as a means of keeping ahead of technological change and engaging in an increasingly interdependent world. Life-long learning reflected the need for imagination and changes in education to be at the forefront as technology brought the world closer together and advances in production methods and automation replaced traditional workforce. “The need, which will be still greater tomorrow, for receptivity to science and the world of science, which opens the door to the twenty-first century and its scientific and technological upheavals” (UNESCO, 2007a, p. 37).

Chapter four of the UNESCO (1996) report *Learning, the treasure within* highlights four pillars of education. These are *learning to know, learning to do, learning to live together, and learning to be*. Learning to know focuses on the knowledge needed both for general understanding but also specific knowledge and understanding related to tasks and required for lifelong learning. This learning may develop out of the discipline knowledges, or vocational knowledge that provides the learner to benefit throughout their life. In the changing roles of education this led to the consolidation of eight learning areas in Australia.

Learning to do relates strongly to gaining useful employment and is broadened to encompass those social skills required to work in teams and deal with complex situations and may include higher education but also reflects the growing importance of informal learning. Informal learning may encompass the need to change direction in work as a result of changing world, national and local needs. The United Nations has been leading the way for developing the importance of people working and living together and solving world problems through social skills for a sustainable future.

Learning to live together recognises the importance of the interdependent nature of living in the twenty first century. In the Australian Curriculum model, the cross curricula priorities were reflected in this pillar.

Learning to be is the fourth pillar and focuses more on the individual and the importance of developing their capacity to the fullest including understanding of their rights and responsibilities. “In that connection, education must not disregard any aspect of a person’s potential: memory, reasoning, aesthetic sense, physical capacities and communication skills” (UNESCO, 1996, p. 37). These individual pointers are strongly reflected in the Australian Curriculum general capabilities.

The Australian Curriculum developed an eight learning area platform based on the Hobart, Adelaide and Melbourne Declarations on Education (Ministerial

Council on Education Employment Training and Youth Affairs, 2008). All states agreed to move towards a national curriculum, and this was a new direction in education as the Australian States, individually, are constitutionally responsible for education, though they have supported the development of the Australian Curriculum. By 2015 half of the national curricula offerings were ratified, with the rest to be implemented by 2020. However, there was even some suggestion that not all broad learning areas would be taught in the primary school, as cited in the Review of The Australian Curriculum Report (Wiltshire & Donnelly, 2014). Whilst these recommendations may have been rejected it highlighted that time available for primary education is limited and prioritising specific learning areas over others may have ongoing repercussions.

In 2017 Queensland Curriculum Assessment and Reporting amended the recommended time allocations for all curriculum areas with an increase in minimum suggested times for   and mathematics, and a corresponding decrease in time for such subjects as art and technology in the primary school. This supported an increased focus on literacy and numeracy, especially in regard to standardised comparative testing such as National Assessment Program Literacy and Numeracy (NAPLAN) and Price Milburn (PM) reading benchmarks. These tests and international comparisons such as Trends in International Mathematics and Science Study (TIMSS) have already placed a strain on resource allocations that teachers and schools apportion in the primary school, including the allocation of time (Benson & Lunt, 2011).

The UNESCO (1996) *Learning, the treasure within*, report provided early warning that there was a danger by formal education systems to emphasise the acquisition of knowledge to the detriment of other types of learning, "but it is vital now to conceive education in a more encompassing fashion" (p. 37). West (2009) suggested that "high achieving countries don't narrow" (p. 10) their curriculum range. Keirl (2011) stated, "the learning areas are not of equal importance" (p. 72). Similarly the influence of literacy and numeracy testing on what to teach and teaching time caused concern in primary schools in New Zealand (Buntting & Jones, 2015).

2.11 Broad v's narrow curriculum

It had been suggested that knowledge could be best taught and learnt by isolating and teaching subject-specific content within disciplines (Phenix, 1962). Hence the move to teaching of content in discipline area 'silos' (Anderson & Gibson, 2004) or, as articulated by a meeting of Heads of Curriculum, Primary, in the Southern Vale Cluster of Schools 2014, by teaching discipline areas by their 'curriculum colours.' The concept of teaching in 'subject colours' is the wording used to refer to teaching in the individual discipline area 'silos' in primary school, with colours as shown by the different discipline colours on the Australian Curriculum Assessment and Reporting Authority curriculum web pages. The arts for example was purple. Gallagher (2012) stated "students rarely see the connection among their courses and rarely see real life connections to the material they are learning" (p. 2).

However, in the primary school there are many links to and across curriculum areas that are best taught in a cohesive integrated classroom (Jones, 2014). "STEM education provides a format for teachers to integrate subjects, specifically science, technology, engineering and math, and make learning more meaningful to students" (Gallagher, 2012, p. 2). This meant moving away from teaching curriculum areas in 'silos' or by their 'colours.' This move away from teaching subjects in silos was a theme at the Third International STEM (Science, Technology, Engineering and Maths) Conference, 2014, Vancouver, B.C. At the conference it was mooted that teachers from various STEM disciplines "take into account in their own teaching what colleagues from each of the other subjects are teaching" (Barlex & Banks, 2014). Simpson et al. (2014) from University of Sydney in a submission to the Review of Australian Curriculum stated as one of their recommendations, "there is a need for broadening conceptualisations of what education is for. The importance of ways of knowing should take precedence over the maintenance of discipline silos through a blind focus on curriculum as content" (p. 3).

The interconnectedness across the Australian Curriculum has some common vocabulary and conceptual points, generally articulated in similar or congruent words or phrases. Congruent words, including 'materials' and 'tools', are found in The Arts curriculum, the Technologies curriculum, and Science curriculum. Similar phrases such as "designing and producing products" (Technologies), "using materials when making artworks" (The Arts), and "design investigations, and describe potential safety risks when planning methods" (Science) (Australian Curriculum Assessment and Reporting Authority, 2014b), and "using and extending fine-motor skills when integrating movements and manipulating equipment, tools and objects" (Health and Physical Education) (Queensland Studies Authority, QSA 2006a, p. 55) are identified in school curriculum documents. The developing of skills and making of products are underpinned by notions of creativity and innovation (Mason & Houghton, 2002).

Creativity and innovation are important components of education for the twenty-first century though not explicitly cited in the curriculum except for critical and creative thinking as a part of cross curriculum priorities (Australian Curriculum Assessment and Reporting Authority, 2014b). "All of the advanced industrial countries comparable to Australia (United States and Canada, United Kingdom, Europe, Asia) favour similar kinds of curriculum reform, shifting from a heavy content focus in science or an instrumental approach to mathematics, towards inquiry, problem solving, creativity and critical skills" (Marginson, Tytler, Freeman, & Roberts, 2013, p. 112). Creativity and innovation are seemingly part of an interconnected link across all curriculum. Development of creative and innovative thinking has links to producing a product (Rasinen et al., 2009), and by association the need to use tools and materials.

2.12 Purpose of education

The purposes of education have changed somewhat over the centuries. Livingstone suggested "for Plato the supreme aim of education is human goodness …. So he conceives education essentially as training in values" (Livingstone, 1944, p. 12). McGrath writing on the purposes of education in America of the 1950s suggests a similar line when he discusses the 'Three R's of Citizenship' where children "learn to live harmoniously" (McGrath, 1951, p. 52).

Over fifty years ago, the United Nations General Assembly proclaimed the Declaration of the Rights of the Child, that included in principle seven a right to a free education (United Nations General Assembly, 1959). This was followed by the UNESCO - World Declaration on Education for All that stated the educational needs of children.

> Comprise both essential learning tools (such as literacy, oral expression, numeracy, and problem solving) and the basic learning content

> (such as knowledge, skills, values, and attitudes) required by human beings to be able to survive, to develop their full capacities, to live and work in dignity, to participate fully in development, to improve the quality of their lives, to make informed decisions, and to continue learning. (Inter-Agency Commission, 1990, p. 1)

This was a shift to recognising the importance of education as a precursor towards future employment. In Australia, Karmel (1976) suggested a similar focus when he stated “matching individual skills to the labour market, increasing social mobility” (Karmel, 1976, p. 8) as goals for education. Bandura (1993) suggested that a major goal of formal education “enable individuals to gain new knowledge and to cultivate skills either for their own sake or to better their lives” (p. 136).

In the latter part of the twentieth century the emphasis for the role of education in providing skills for jobs became even more refined with emphasis on jobs in a changing technological world. Science, Technology, Engineering and Maths (STEM) skills became paramount. The STEM acronym was “first coined as an educational term by the National Science Foundation (NSF) in the early 2000’s” (Dugger, 2010, p. 2).

A 2012 UNESCO published a paper titled, ‘The challenges of Creativity’ stated “creativity is the key to innovation, itself a key international concern for education and training in an increasingly competitive world” (Haddad, 2012, p. 1). The realization was that the best way forward within a modern technological world was with workers who have a solid understanding of STEM subjects and who are creative and innovative.

The 2014 Australian Innovation System report (Office of the Chief Economist, 2014) reflected upon the need for innovation across industry both domestically and internationally, for the benefit of the economy and maintaining Australia’s standard of living. Ian Chubb, Australia’s Chief Scientist argued a similar line in the push to increase STEM research for Australia’s future stating “STEM education and innovation are essential for the nation’s success” (Head, 2014, p. 30). In December 2015, the Education Council identified that STEM knowledge and skills start in early childhood and develop throughout primary school and linked it to building on a child’s curiosity and it highlighted as part of its first goal (Education

Council, 2015). These sentiments were subsequently reaffirmed in the Australian Curriculum Assessment and Reporting Authority STEM connections report when referring to STEM as being the disciplines integrating learning to develop children's curiosity and improving "students' problem-solving and critical analysis skills" (Australian Curriculum Assessment and Reporting Authority, 2016, p. 4).

2.13 Creativity and innovation

By 2015, a further refinement to educating for future occupations came to include a focus on creativity. This changed the focus on STEM education to include creative subjects especially visual arts with countries such as South Korea, United States (Yakman, 2012), and England (Neelands et al., 2015) discussing STEAM (Science, Technology, Engineering, Arts, and Maths) as an educational imperative. "We are all aware that more graduates with skill and knowledge in science, technology, engineering, and mathematics (STEM) will drive economic development" (Gatsas & Baines, 2013). Political, educational and social leaders in the United States (Sawyer, 2012) and the United Kingdom (Neelands et al., 2015) have indicated the growing awareness of the importance of creative thought in STEM for economic success. Runco (2004) suggested that "all of this implies that creativity is more important now than ever before" (p. 658).

There are those, especially from an 'instructionist' (Sawyer, 2012, p. 395) point of view that suggest that creativity cannot be taught. "Creativity, or the urge to explore and invent without knowing in advance how useful the outcome maybe, cannot be taught, but it must be detected, recognised and encouraged" (Mason & Houghton, 2002, p. 1). However, most recent studies (Sawyer, 2012) have indicated that in the broad spectrum of creativity definitions, especially in the social creativity realm, creativity can be encouraged and taught. Sawyer suggested that the research indicates that "creativity requires a high level of domain knowledge; for example, it takes ten years of hard work mastering a domain before one can make a creative contribution" (Sawyer, 2012, p. 390). This is indicative of discussion on 'Pro-c' creativity in the Four C model of creativity (Kaufman & Beghetto, 2009). The Four C model suggests that creativity is a complex concept able to be viewed at four levels, mini-c, little-c, pro-c and big-c. For primary school discussion, creativity is most likely in the realm of 'Mini C' which focuses "the dynamic, interpretive process of constructing personal knowledge and understanding within a particular sociocultural context" (Kaufman & Beghetto, 2009, p. 3).

Discussion on creative ability of young children suggested that creativity can be fostered and developed (Benson & Lunt, 2011; Cloninger, 2010). "Recent research demonstrates that creativity and a problem solving approach to design and technology education is central to today's global society" (Trevallion & Owen, 2012, p. 138). This linking of education and creativity indicates that creative and innovative skills, dispositions and practices can therefore be encouraged, developed and taught.

The origins of being creative and innovative in formal education settings are to be found in primary school. "There is strong agreement amongst leaders and staff across all education sectors that it is important to support children and young people to develop creativity skills, in order for them to function well in the future" (Education Scotland, 2013, p. 9).

Davies et al. (2013) research identified three key aspects for creativity to grow and develop within primary schools including physical environment, pedagogical environment and partnerships beyond schools. The physical environment included the "flexible use of space and resources, provision of appropriate materials and tools, including formless and digital ones, working outdoors and beyond the classroom" (Craft, Cremin, Hay, & Clack, 2014, p. 17).

The Melbourne declaration as well as mentioning the breadth of content and subjects to be taught in the compulsory years of schooling in Australia also mentioned the need for critical, innovative and creative thinking (Ministerial Council on Education Employment Training and Youth Affairs, 2008). Therefore, it is important to locate innovative and creative thought within the Australian Curriculum. Creativity was mentioned along with critical thinking in the general capabilities of the Australian Curriculum (Australian Curriculum Assessment and Reporting Authority, 2014b). "Creative play is vital for children's overall development and has shown amazing results in helping to develop a child's imagination, problem solving and motor skills" (Stalling, 2014, p. 17). Perry and Dockett (2002) cite several studies including Rogers (2000) and Perry and Conroy (1994) highlight the importance of block, water, sand and dramatic play in the development of mathematical ideas in children. Lucas and Smith (2018) in reporting on the benefits of early learning cite several studies that refer to play and crafts as essential for developing creativity and curiosity.

However, there is increasing concern identified in the literature, both here and overseas that there is not enough focus on creativity and innovation in the curriculum (Neelands et al., 2015) especially in the arts, science, technology, engineering and mathematics areas. “There is growing concern that the United States is not preparing a sufficient number of students, teachers, and practitioners in the areas of science, technology, engineering, and mathematics” (Kuenzi, 2008, p. 1). The Warwick commission in England stated that “there are major concerns that the educational system is not focussing on the future needs of the cultural and creative industries and the broader needs for innovation and growth in the UK” (Neelands et al., 2015, p. 45). “Societies today have a great need for creativity in science, technology, engineering and math” (Sawyer, 2012, p. 390). However, the review of the Australian Curriculum, 2014 indicated that there was a recommendation to remove technologies as a learning area from primary school suggesting that “this learning area should be introduced from Year 9” (Wiltshire & Donnelly, 2014, p. 217), though this recommendation was not acted upon.

“Creativity is the generation of a product that is judged to be novel and also to be appropriate, useful, or valuable by a suitably knowledgeable social group” (Sawyer, 2012, p. 8). Therefore, creativity was mostly linked to the curriculum areas that involve making products. Consequently, it was very closely linked to the STEAM curriculum areas taught in the primary school. This inclusion of creativity and innovation within curricula requires a similar understanding of the term’s ‘creativity’ and ‘innovation’ and a focus in education from early childhood onwards. “Innovation is the implementation of a new or significantly improved product (good or service), process, new marketing method or a new organizational method in business practices, workplace organization or external relations” (Office of Chief Economist, 2014, p. 1). According to Haddad (2012), “Creativity is the key to innovation” (p. 1).

Many of the definitions of creativity and innovation alluded to the manifestation of creativity through the making of a product, and in the making of a product some risk must be accepted by both the teacher and child. “Teachers that can model a risk-taking attitude can play a pivotal role encouraging a cognitive playfulness in students and support creativity by promoting cognitive adventurousness, independence, and flexibility in thinking" (Harris & De Bruin, 2018). In providing creativity as part of learning, it was incumbent upon the teacher to provide opportunities that allow the student to make a product. The teaching process must provide the skills to allow this to happen, including access to resources and to dispositions that allow learning in constructing a quality product, the standard of which will be dependent on the students' abilities and skills training. "Specifically, pupils should be taught to work with tools, equipment, materials and components to make quality products" (Rasinen et al., 2009, p. 35).

Parallel to the developing importance of creativity and innovation in education and employment are the psychological and physiological theories on how children develop into active and creative members of society. Piaget, Vygotsky, Gardener and others discuss the importance of children developing through stages from concrete to abstract (Duschl & Hamilton, 1992; J. Fox & Schirrmacher, 2011; Gardner, 2006; Morris, 1976; Snowman, 2009). The use of and interaction with manipulative objects including equipment, tools and materials are part of this development and assist in developing other dispositions associated with children's development such as self-confidence (Council of Australian Governments, 2009; Konstantinidou, Gregoriadis, Grammatikopoulos, & Michalopoulou, 2013; Penfold, 1988), collaboration (Sheet-Johnstone, 2000), persistence (Bandura, 1993; Collard & Looney, 2014), and resilience (Fleer, 2004; Queensland Studies Authority, QSA 2006a).

2.14 Tools, materials and adhesive methods

From the Australian Early Years Curriculum Framework, through the Australian Curriculum to the Vocational Certificate Three in the Australian Qualifications Framework there is mention of tools, materials and adhesive methods, and of growing skill level in the use of tools (Australian Curriculum Assessment and Reporting Authority, 2018a; Queensland Studies Authority, QSA 2006a; Torrance, 1977) (see Appendix One). Craig and Deretchin (2010) and J. Fox and Schirrmacher (2011) discussing early childhood creative development, have indicated the importance of making in the development of creative and innovative thinking as well as social skills of persistence, resilience and cooperation.

Safety in the use of tools is mentioned as well as with materials and adhesives though not specified even within the elaborations of the various curriculum areas. Anning “saw simple tools like scissors and brushes being incorrectly handled” (1993, p. 40). Seiter (2009) suggested that “the use of materials and tools is basically not subject to any limitations as long as they are suitable for the age and development of the children and, above all, do not present any danger to their health” (p. 473).

The Australian Curriculum: Technologies subject, ‘Design and Technologies’ (Australian Curriculum Assessment and Reporting Authority, 2014e) stated that students in year two will “select and use materials, components, tools and equipment using safe work practices to make designed solutions” (ACTDEP016); and by year five, “apply safe procedures when using a variety of materials, components, tools, equipment and techniques to make designed solutions” (ACTDEP026). These two statements reinforce that primary school children will use tools that they are proficient and safe at, and that the variety of tools increases across the primary years.

In the visual arts component of the Australian ‘The Arts’ curriculum it states “use and experiment with different materials, techniques, technologies and processes to make artworks” (ACAVAM107), and in year four states, “use materials, techniques and processes to explore visual conventions when making artworks” (ACAVAM111) (Australian Curriculum Assessment and Reporting Authority, 2014a).

In Science the following statement is in year three: “safely use appropriate materials, tools or equipment to make and record observations, using formal measurements and digital technologies as appropriate” (ACSIS055) (Australian Curriculum Assessment and Reporting Authority, 2014d). Pound (2011) discussed physical skill development and highlighted those skills that are deemed vital including cutting, joining and folding of materials. At the same time the role of the teacher was to teach safety and risks of using tools, materials and adhesive methods. This weighing up of risk included the consideration of the effect on children’s development if we do not help children to manage potential dangers when using tools.

“The task of creating learning environments conducive to development of cognitive skills rests heavily on the talents and self-efficacy of teachers” (Bandura, 1994, p. 8). Therefore, teachers must feel confident and competent in using tools materials and adhesives in the classroom if they are to fully engage students in using them.

1.1.1. Identifying tools and materials in the curriculum

The use of manipulative tools, materials and adhesive methods is identifiable across various curricula, including maths, science, technology, and the arts, in the primary school in general terms. There is a suggestion of skill development yet no specific scope or sequence or guidelines articulated as to what tools, when to implement them, or how to develop skills were identified in the Australian Curriculum. However, this was not always the case, in the 1952 syllabus ('Queensland Department of Public Instruction, 1952) for the upper primary school years included for example, grade seven tools “to understand the use of the following tools rule, try square, marking gauge, dividers, tenon saw, firmer chisel, mallet, jack plane, winding lathes, bevel, brace and bit, oilstone, hammer, bradawl, nail punch, ripsaw and bow saw” (p. 97); and in year five needlecraft “ further practice in the use of scissors – cutting slanting lines, curves, etc” (p. 81). In following curriculum documents into 21st century there is mention of tools in a generic sense but without mention of why specific tools have been removed.

Appendix One indicates some of the cross curriculum uses of tools and materials in the primary school. There are common associative words or phrases in the STEAM subjects that are taught across the primary school such as: construct, make, model, use scaled instruments, create, use materials, manipulate, produce, and explore characteristics of materials and components. Within these words are the understandings either explicitly or implicitly that the students will use tools, materials, and adhesive methods to make something; a product. There is also a focus on the interconnectedness of curriculum areas such as science and technology, to promote the products children are making. This is similar to the Scottish curriculum that allows “opportunities for interdisciplinary and cross-curriculum working that can provide a framework for integrated approaches to assessment” (Education Scotland, 2013, p. 2). Specific lists of tools for each year level are not able to be located though suggestions for tools in primary schools are available. Studies have identified tools used in the primary school as a general whole of school list rather than specified for a year level or as a developmental programme of instruction (J. Fox & Schirrmacher, 2011; Hohmann, 1995; Makiya, 1992; Rasinen et al., 2009).

These studies, as well as personal experience will provide a basis for identifying tools and materials for use in the survey for this study. Fox (2011) provided an explanation of the importance of the manipulation of tools for refining large and fine motor skills and hand-eye coordination and suggested that manipulative tools must be individually introduced through modelling by the teacher and that children practise the correct way to handle and use tools. Johnsey (1998) also highlighted several tools and materials that would be useful within the Australian primary classroom such as scissors, motors and card, but indicated that children "need to consider two major aspects of their work in design and technology with regards to health and safety" (p. 125) that regarding making the product and that of those that use the product.

2.15 Suitable tools, materials and adhesive methods for primary schools

Alaezi (1988) indicated a broad range of tools and materials used in primary schools in Nigeria including "hoes, knives, cymbals, hammers" (p. 30) for the production of a range of products including "beds, statues, doors, leather, bells, shovels, spears, hoes, screws, cutlasses, keys, rings, pots, traps, knives, forges" (p. 30). These are directly related to the provision of basic education for the provision of work skills in the local community and whilst these may not be suitable in the Western world they do indicate the potential range beyond a narrow understanding of what tools could be used in the primary school by young children.

Hohmann (1995) suggested an even broader sense of tools for young children citing, "mops, buckets, sponges, hammers, saws, hand-drills, vices, nails, screws, staplers, hole punches, scissors, paper clips, bicycle pumps, shovels, hand trowels, hoes, hoses and watering cans" (p. 30). Further, for the arts, she suggested the following, "heavy duty staplers, hole punch, paste, liquid glue, glue sticks, masking tape, clear tape, elastic, pipe cleaners, wire, string, yarn, ribbon, needles with big eyes, thread" (p. 135). Makiya (1992) made suggestions for a class set of tools, see Table 1.

Cryer (1996) suggested that “fives need to have many creative materials every day to use in their own way so that their skills can develop” (p. 209) and includes suggestions of fabric and yarn. She further explains that tools “should be real tools of the right size not play tools” (Cryer, 1996, p. 248) before suggesting a range of tools such as carpentry tools including hand drills, hammers and saws. These suggestions influenced the range of tools, materials and adhesive methods in the design of the survey in the study.

2.16 Self-Efficacy

Bandura’s (1989) research on self-efficacy suggests that students’ resilience and persistence can be developed and that “training in cognitive skills can produce more generalised and lasting effects if it raises self-beliefs of efficacy as well as imparts skills” (p. 733). Furthermore, Bandura (1989) suggested that self-efficacy inducing approaches (to training) include “direct mastery experiences” (p. 733). This includes confidence and mastery in the use of tools, “as people strive for certain goals or levels of competence and receive social feedback from time to time concerning their performance” (Bandura, 1993, p. 123). Also, Bandura highlights if students don’t get opportunities to practise the skills and develop their self-efficacy, they quickly abandon those skills.

The STEM connections project stated among its aims were to “improve the confidence of students in STEM and their capacity to transfer knowledge, understanding and skill across STEM subjects and contexts” (Australian Curriculum Assessment and Reporting Authority, 2016, p. 5). In their conclusions, Davies et al. (2013) highlighted some critical aspects in schools ability to promote creativity including, “the physical environment, availability of resources/materials, use of the outdoor environment, pedagogical environment, use of other environments beyond the school, play based learning, effective and flexible use of time, and relationships between teachers and learners” (p. 88).

Whilst student self-efficacy is critically important to a child’s growth, the self-efficacy of the teacher is also critically important in the provision of opportunities for students to engage with the use of tools. “The task of creating learning environments conducive to development of cognitive skills rests heavily on the talents and self-efficacy of the teachers" (Bandura, 1993, p. 140).

In her study on design and curriculum in primary schools Benson (2013) found that teachers used a bank of activities that they were already comfortable with. These activities may be based upon past successful teaching experiences or on experiences they are confident or competent in. This comfort led von Mengersen (2013) to suggest that teachers should use needle craft because of its creative potential even though it "has long fallen out of fashion" (p. 355).

Therefore, in developing STEM skills to enable teachers to engage with expanding their confidence in tools to include new and emerging tools and materials with children in the classroom they must have skill development that allows them to feel comfortable. Then when working with children opportunities need to be provided that allow for practice of those skills.

2.17 Chapter summary

This chapter provided a broad understanding of the literature that supports the development of the whole child including the links emerging between physical and cognitive growth. It highlighted the rights of the child to grow within a cultural setting that does not undermine the rights to a happy and healthy childhood. Rather it encourages providing opportunities to maximise a child's learning to their fullest capacity. The chapter provided understandings of the importance of children engaging with tools and materials from an early age to develop strength and competence in the manipulative skills that would enable them to use these skills across many future endeavours including vocational skills.

The chapter reinforced the importance of science, technology, engineering, the arts and mathematics as disciplines for the future prosperity of all. The chapter underscored that the child's future is and will be different from the past. There is increasing need for skills for the twenty-first century, where collaboration, communication and risk taking are a necessity in problem solving whilst highlighting the need for training in the possible use and safety of tools, materials and adhesive methods as well as the need to consider ethical and sustainable uses.

Chapter Two identified many examples of tools and materials used across the world in primary schools. The next chapter, Chapter three, focuses on the methodology used in the study and reflects the tools and materials identified and the reasons why a survey and interviews are used in this research.

3 Methodology

3.1 Introduction

Chapter three will begin with a review of the background of the researcher and the reasons for the research. The questions proposed in this exploratory study are to identify what tools, materials and adhesives are actually being used in the primary school from a compiled list presented within a survey. The list will indicate when and how often the listed tools and materials are used. Once ascertained further in-depth questions could be asked that include when the tools, materials and adhesives are introduced and factors influencing those decisions.

3.2 Epistemological underpinnings

Dewey (1971) explored the interactions of physical things, the making of sense and the importance of language. My understanding of Dewey is not that a tool such as a a paper scorer has sense rather that the user gains from experiences in interactions and reflections with the tool. “That is to say, differences in qualities (feelings) of acts when employed as indications of acts performed and to be performed and as signs of their consequences, mean something” (Dewey, 1971, p. 211). Experiences form a critical and integral aspect of learning and follow a developmental path which underpin work of others such as Piaget and Vygotsky. However, it should be noted that Dewey’s concept of experiential learning is made up of “the organism interacting with its physical and social world”(Muhit, 2013, p. 12)

The conceptual ideas of child psychologists Piaget and Vygotsky, and child cognitive development and constructivist theories are influenced by Dewey. Piaget suggested in his theories that children develop through stages of cognitive development with interaction with the environment. Children progressed through their understanding based upon a biological timeline. Piaget (1964) theory has children progressing through four discrete stages of development, ‘sensory motor’, ‘preoperational’, ‘concrete operations’ and ‘formal operations.’

Kolb (2015) in his book on experiential learning presents a model that builds on Dewey, and links with Piaget and Vygotsky as well as Mary Parker Folley, Kurt Lewin and Carl Rogers to name a few (Chapter 1) before highlighting and developing his four stage “experiential Learning cycle” (p. 51) including Hand-on, Minds-on. However, in his article reflecting on Dewey and Kolb Miettinen (2000) suggested that a difference of interpretation between the two occurred because “Kolb speaks about experiential learning. Dewey speaks about experimental thought and activity” (p. 70)

The concept of hands-on minds-on further has further links to active engagement of the learning process with children. (Fluckiger, Dunn, & Wheeley, n.d. C2016) stated that active learning “requires physical and embodied engagement across all areas of learning. Whether this is indoors or outdoors, activity is essential to activate children’s full potential” (p. 28). The concept of active learning and embodiment is further underscored in the Australian Curriculum links cited such as history and geography, and the arts including “embodied symbol making”(Fluckiger et al., n.d. C2016, p. 27).

My classroom experiences (1.4) resonated well with the constructivist theories of Piaget and Vygotsky. Piaget’s theory of child development highlighted that children construct their own understanding through active participation “and interaction in their environment” (Papert, 1980, p. 156) in the learning process developed from a Deweyan perspective of understanding as being a “transaction between and organism and its environment” (Kivinen & Ristela¨, 2003, p. 364). Piaget also indicated the importance of prior knowledge. Vygotsky added to the constructivists paradigm by indicating the importance of social interaction and language in constructing understanding, “mediated by other people through shared activity and language ” (Bodrova, 2007, p. 106). Vygotsky suggested that children construct understanding through social interactions and make meaning through communication and collaboration especially with regards to cultural tools or artefacts. These artefacts may include tools and materials (Shabani, Khatib, & Ebadi, 2010). Vygotsky’s contribution to constructivism and child development focussed upon scaffolding children’s learning based upon his zone of proximal development. The learning and teaching role of the teachers and class peers in the construction of an individual’s understanding is critical.

Papert (1980) added to constructivist theory by developing his ‘Constructionist’ ideas stating, “educational intervention means changing the culture, planting new constructive elements” (8). Further, Papert (1991) suggested “Constructionism evokes the idea of learning by making” (p. 6) and building on the social nature of collaboration suggested combining "hands-on and heads-in" (Harel & Papert, 1991, p. 150).

As a pragmatic constructivist and active leader in STEAM education I have presented often and widely, always with a practical component, especially in the local schools and community. This means that I have had prior contact with many of the teachers and schools that participated in my research. There was a growing concern voiced in these workshops about the physical capability of children to complete manipulative tasks in a safe and timely manner, especially when using everyday tools and materials.

Currently there is little background research available on the specific types of tools, materials or adhesive methods used in primary schools with no identified studies citing Australian or more specifically Queensland schools. To this end this study attempted to identify trends in what tools, materials and adhesive methods are currently being used by children, a sense of timing as to when tools are introduced, and an indication of what skill development is, or has been accessed by teachers.

Further to these researchers informing my pragmatic constructivist epistemological stance is the addition of Erikson's theory of social development. He suggested in his in his theory of social development "if children at this stage are encouraged to make and do things well, helped to persevere, allowed to finish tasks, and praised for trying, industry results" (Snowman, 2009, p. 26)

3.3 Mixed Methods Methodology

Pragmatic constructivism as suggested by J. Creswell (2014) provides the underpinning philosophical viewpoint for this study, allowing the "mixed methods research in that inquirers draw liberally from both quantitative and qualitative assumptions" (p. 11). As an introductory study on identifying what tools are being used in primary schools a broad, point in time method to identify specific items is needed. Creswell (2012) and Wiersma (2005) recommended that the best method for gaining this type of information may be by survey. J. Creswell (2014) stated if "you seek to describe trends in a large population of individuals. In this case, a survey is a good procedure to use" (p. 12).

However, gaining a listing of tools and when they might be implemented in the classroom does not provide an understanding of the underlying reasons and factors affecting the use of tools, materials and adhesives such as safety and expertise. To this end consideration needs to be made of the factors directly affecting the teacher and the classroom and assessing this may be best done by talking to the teachers to identify and clarify specific issues regarding use of tools, materials and adhesives in the classroom.

Whilst the collection of numerical data may be best suited to a quantitative study, reasons behind factors influencing the selection and development of tools, materials and adhesives may best be researched using qualitative methods such as interviews. Therefore, the indications are that both methods together are best suited to gain an accurate understanding of the research problem; consequently a mixed method design (J. Creswell, 2012; Wiersma, 2005) to the research was planned, with quantitative dominance (R. B. Johnson, Onwuegbuzie, & Turner, 2007).

The study will comprise three phases based on Creswell's (2009) Sequential Explanatory Design as shown in Table 2. "Explanatory sequential mixed methods is one where the researcher first conducts quantitative research, analyses the results and then builds on the results to explain them in more detail with qualitative research" (J. Creswell, 2014, p. 15).

Table 2

Sequential Explanatory Design

Sequential Explanatory Design				
Quan (Quantitative)		Qual (Qualitative)		
Data collection	Data analysis	Data collection	Data analysis	Interpretation of entire analysis
Phase 1		Phase 2		Phase 3

(Creswell, 2009, p. 209)

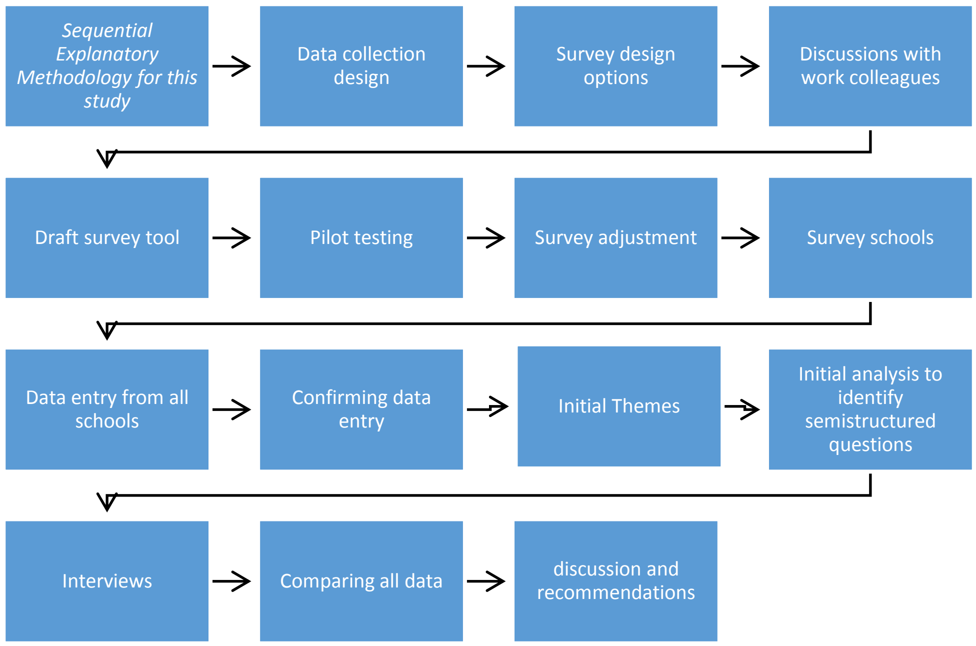

Figure 13 Expanded Sequential Explanatory Methodology for this Study

3.3.1 Sequential exploratory methodology

The purpose of the study was to identify what tools, materials and adhesives were being used in primary schools in Southern Queensland. Figure 13 provides a specific overview of the sequential process followed in this study. Phase one of the study has an initial focus on quantitative data collection from a large sample, using a survey to identify specific tools, materials and adhesives used in the primary school, and such information as year level, whether the tool, material and adhesive use by children is done on an ad hoc basis or developmental basis. The quantitative method most able to gain specific knowledge from a large number of participants is the survey method. J. Creswell (2012) indicated an eight-step process for implementing a survey. Step one included a decision that the survey was the best design to collect data, with step two to link to the research question. To establish a draft list of tools for the survey, the researcher completed a scan of the literature and personal knowledge. Step three was to identify the population and sample. Step four was to identify the survey design and data collection procedure, then develop or identify an instrument. Step six was to administer the survey and then collect and analyse the data. Step eight was on the writing of the report.

3.3.2 Data collection type

For this study the survey could have been open ended with asking teachers to reflect upon the tools that they were going to use during the year and ask them to write a list. The other option was to provide a list of tools, that teachers would use to indicate that they used or did not use with the children in their classroom in an ad hoc manner or in a developmental instructed way. Both methods were discussed with classroom teachers and administrative staff at my school.

3.3.3 Survey design options

The discussion with work colleagues about both survey designs, saw pluses and minuses for each. The open-ended survey idea teachers thought that they would not have enough time to reflect on all their possibilities and would miss some particular items. A suggestion that a semi-structured list with broad areas such as cutting, and hole-making was also considered but led to needing more detail in what was encompassed by such areas. Specifying the tool was decided upon with the researcher being available with tool samples to explain if necessary, at the point of survey delivery. There was also the problem of time allocated for the completion of the survey with no suggestions as teachers would be expected to write significantly more. The second option was to develop or modify a school-based list of tools. This was the preferred method, though it concerned some teachers who had not engaged with nor considered tool use; however, regards to not engaging with many tools, though the administrative team liked the idea of a list because of the fifteen to twenty-minute time allocation in the staff meetings as highlighted in the ethics proposal.

3.3.4 Discussion with work colleagues

The next stage was to use or modify an existing list, or develop a new list as suggested by J. W. Creswell (2018). A search of research literature did not identify a list of tools, materials and adhesives used across the primary school which meant that a list could not be modified or used. Isolated instances of suggested tools were included in journal articles and pedagogical books such as(Alaezi, 1988; Makiya, 1992). These suggestions were further added to by classroom activity suggestions from for the use of tools and materials (CLOHE, 2011; Cryer, 1996; Heroman, 2017) as well curriculum support documents (Australian Curriculum Assessment and Reporting Authority, 2018f; Department of Education and Training, 2015b). A list was developed that took into consideration of these tools, materials and adhesives as well as the professional experiences of the researcher, as indicated 1.4.

3.3.5 Draft survey tool

The list of tools, materials and adhesive methods was developed as in appendix 2. This fitted the design parameters of being able to be fully on one A3 page folded and being able to be completed by teachers in the survey within the time constraints of fifteen to twenty minutes. The survey form had a section for demographics and description of task with separate pages for tools, materials and adhesives. Th e final page had space for teachers to make intial commentry. The inclusion of many tools and materials limited the available space for teachers to add other examples of tools, materials and adhesive methods to a single space on page two and further space in the comments on the last page of the survey.

3.3.6 Pilot testing

Once the survey was constructed it was taken to a single pilot school to be field tested. All the teaching staff at that school were involved in the pilot including the principal. This field testing of the survey had three main factors. The first was to ascertain that the survey form questions were satisfactory or could be improved. The second was to confirm that the time required to complete the survey was appropriate. The time was allocated by the principal of the school in their weekly staff meeting with a time of fifteen minutes which the principal monitored. The third factor was to ensure that the items were appropriate to the classroom teacher.

3.3.7 Survey adjustment

The survey was able to be successfully completed within the time frame. Adjustment was made to the order of some materials due to initial misunderstanding between sheet metal and foil. In the pilot no teachers took the opportunity to reflect further in the study and send the survey in in supplied postage paid envelopes. The final draft was made and distributed at the other schools participating in the study.

3.3.8 Survey schools

Schools within the Darling Downs and South West education region of the State of Queensland were contacted as per the permissions required in the ethics application. Many schools were contacted and all schools that indicated that they would participate were contacted to make time suitable to the schools and teachers.

Further detail is elaborated upon in 3.4 Phase One. Schools did not receive any recompense except for heartfelt thanks of researcher.

Survey distribution was by researcher visiting schools personally and collecting data during designated time in a staff meeting authorised by the principal. At this time teachers were also invited to advise if they would like to be part of a follow up interview to clarify comments from the survey. This was a maximum thirty-minute time of their choosing.

3.3.9 Instrument Design and Validation

This study was to identify what tools, materials and adhesive methods are used in the primary school and when they are introduced. There are many opportunities for researcher bias in a study such as this that can affect the validity of the study. Some of the potential influences on validity are impacted by pragmatic views of the researcher themselves. For example, in this study, compiling a list for the survey the researcher needed to call upon their own knowledge and experiences as a start point, bringing into question the affinity with the school teachers and their contexts. Also the timings of giving the survey during a staff meeting raises concerns of time and place. Norris (1997) listed a range of potential sources of bias including "Selection biases including sampling of times, place, events, people, issues, questions and the balance between the dramatic and the mundane" (p. 174).

In compiling a reliable list from which to identify which tools, materials and adhesives methods and the researcher needed to be aware of the validity of the selected examples, "as reliability is a consequence of the validity in a study" (Golafshani, 2003, p. 602). The validity of the instrument must be ascertained. Researcher bias in the compilation of the survey instrument could be partially alleviated by using a list of tools, materials and adhesive methods from previous studies or by the school, State, or Australian Curriculum documents. As the literature search showed, there was no such list. The researcher constructed their own list and needed to be aware of bias. For example, if in the list, the researcher only focussed upon tools and materials that he was interested in the list may only contain tools to construct or deconstruct a computer such as pliers, soldering iron, mini screwdrivers and Allen keys. This list may be valid if the study was about computer tools but that was not the focus of this study, the focus was all the tools, materials and adhesive methods used across the primary school. Greewood and Levin suggested validity is made where “an indeterminate situation is made determinate through concrete actions in an actual context” (Denzin & Lincoln, 2005, p. 53).

The data was compiled and coded into a “master list” (B. Johnson, 2004, p. 504) in Excel 2016, which included the coding for use in statistical analysis programme SPSS, an example is shown in appendix 4. However, this method of analysis was not suited to this research as there was only two possibilities in each response, either the element was used or not used. The researcher decided to use the Excel programme and collate and present the data. The data showed what tools, materials and adhesive methods were being used in the classroom and those that were not, as well as whether they were used in an ad hoc manner or a developmental manner.

Once the survey data had been entered the themes emerging from the study were investigated. To support the emergence of themes several methods were trialled. Colour coding and repeating words were identified to assist in locating similar concepts (Ryan & Bernard, 2003). Within the collated master document of the interviews NVIVO was trialled, however the researcher inexperience in using the technology did not add to the identification of themes. The themes and data from the study were used in the compilation of semi-structured questions used in the interviews. These questions were able to assist in ensuring that researcher bias during the interviews was minimised with the compilation of the semi-structured questions for the survey, as was the link back to the survey sheet. Sample questions included three types. Initial analysis of the survey data including comments laid the groundwork for the semi-structured questions for the interview, linked to the research questions. The Questions from the survey included (a) why specific tools were used, as well as reasons, (b) why expected tools were not used, (c) specific tools initiated by the interviewee. These questions regarding tool use also led to queries regarding the links to materials used, an example of which was regarding how wood might be shaped in the primary school without using a saw.

To assist with the reliability of the survey data, a sample number of twenty participants that identify with each year level from Prep to Year Six were needed to respond to the survey. Therefore, to assist in the spread of teachers across all the primary years, all teachers in schools that agreed to participate were asked to complete the survey. The sample was selected from the “target population” (J. Creswell, 2012, p. 381) of primary school teachers within the schools surveyed, in Southern Queensland.

In phase 2, a small sample of twelve teachers (N=12) were interviewed. Using semi-structured interview questions that were identified, elaborated and developed from phase one. To reflect the diversity of teaching and to reflect a broad range of teaching beliefs, systems teachers from both public education sectors and religious schools were asked to participate in the interviews. Teachers were selected from respondents at the time of survey. The teachers indicated the times that would be suitable to be interviewed. Some teachers nominated lunch time and others after school. The interviews were recorded on a portable voice recorder and transcribed by this researcher into a Word document.

The reason behind the researcher transcribing was to ensure get a sense of the context from the respondents such as tone of voice and exclamations. There were some technical problems with the recordings in two interviews which caused a break in the recording. As well as the technical issue, teachers recording at lunchtime also had some interruptions in the primary school by children needing assistance, other teachers and sounding of bells and sirens. The interviews were transcribed and then collated into one Word document and each new interview started on a new page. The pages were numbered in the footer and totalled one hundred and twelve pages, and some thirty-eight thousand words in total.

For the purpose of this study and to assist in maintaining the confidentiality promised to each participant, the teacher responses will be referred to in total as interviews and page number (Interview P 74). To further ensure the anonymity of the interviews will not be arranged in year levels rather they will be entered as completed.

3.3.10 Data entry from survey

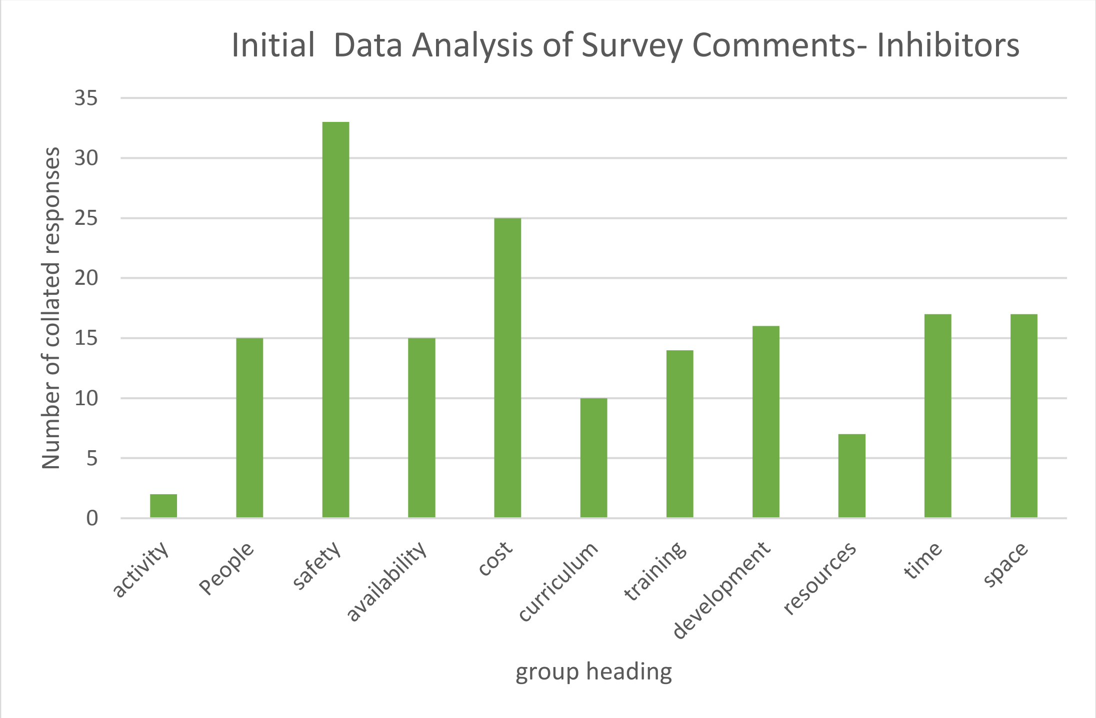

Figure 14 Themes evolving from Survey-

Data was collated from the survey specifically from the section titled – 'Please indicate inhibitors to using tools materials and adhesives in your classroom'. Here the data was collated using synonyms and same words to identify some themes from the data, for example safety and people. Safety included concerns regarding behaviour of students, allergies, safety. Allergy concerns were related to fabrics and adhesives. People included teachers, aides, school administrative staff, parents and caregivers. Availability to tools materials and adhesives included access to class sets, maintenance and class activity. Cost included such thing as school budget, class budget, student finances and teacher costs. Curriculum included C2C, Australian Curriculum, Queensland curriculum and integration of the curriculum. Training referred to teacher, teacher aide, administration and student training. The developmental levels of children influenced the type of tools that were deemed satisfactory for the age level by teachers. This was influenced also by strength and knowledge of students. Materials and resource access was indicated by teachers in this area.

3.3.11 Semi-structured questions and interviews

Initial analysis of the survey data including comments laid the groundwork for the semi-structured questions for the interview. The Questions from the survey included (a) why specific tools were used, as well as reasons, (b) why expected tools were not used, (c) specific tools initiated by the interviewee. Example of questions using tools

(a) Tweezers from Figure 31. Manipulative tools total. led to the semi-structured question, “One of the tools that was most commonly used was tweezers, why do people use tweezers?” (p. 1)

(b) Stanley knives and scalpels from *Figure 29* - “Very few people indicated that they used sharps, either scalpels or Stanley knives or things like that, why might that be?” (Interview p.32).

(c) Saws from Table 9 “So you don’t see tools as part of the curriculum?” (Interview p.2) “No we used to do things like carpentry and that in the old preschool, like carpentry carpentry-tables and things like that skills and saws”.

The responses for the survey were colour coded and tabulated using Excel according to the themes that emerged from the initial analysis that led to the semi-structured questions. Nvivo was also used to collate word synonyms in an initial analysis and shown visual representations shown in the initial word count query as shown in the Figure below.

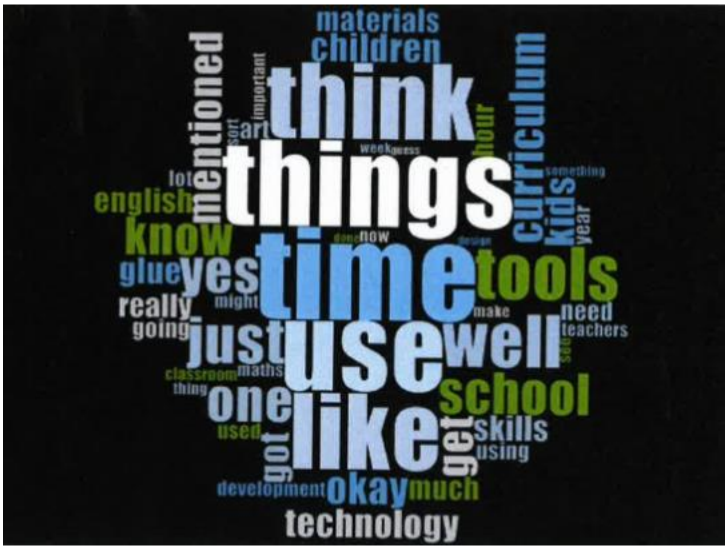

Figure 15 -Initial word count analysis using Nvivo

3.4 Demography

This exploratory research study was designed to identify tools, materials and adhesives used in the primary school by the children, and to try to identify when the tools were introduced across the primary year levels of schooling. The investigation focussed on tools, materials and adhesives children were introduced to and used in the primary classroom, by asking their teachers. It would have been difficult to identify underlying reasons for access and choice of materials and tools from asking the children directly through a survey, as well as identifying a single mechanism that allowed for children from prep to year six to record what tools they were using. Therefore, the focus was on the teaching staff that work with children in the classrooms of South and West Queensland Primary schools. As it was not possible to ask all primary teachers in the region a selection was made.

Sampling from a population of teachers to generalise to the target population is possible according to Creswell (2012) who defined survey populations as follows; “the population is the group of individuals having one characteristic that distinguishes them from other groups” (p. 381). For this study, the population is all teachers in the primary school within the region that work directly with the children.

J. Creswell (2012) stated that “the target population or sampling frame is the actual list of sampling units from which the sample is selected” (p. 381). These units have been determined as the primary schools where the groupings of teachers are the teaching staff at that school. The primary schools are those that have been linked to approval through the ethic application processes of the various education systems. The list of approved schools included both large and small schools from both Catholic and State systems, and from semi-rural and urban areas.

"The sample is the group of participants in a study selected from the target population from which the researcher generalises to the target population" (J. Creswell, 2012, p. 381). This sample is taken to be all the teachers that work directly with children within the school that were selected to participate. The teachers in this group included specialist teachers and lead teachers, with the total number of teachers responding (N=172) being the sample.

After gaining ethical approval to approach schools both from the University, and State and Catholic education systems, schools were invited to participate in the study, ensuring a range of schools were invited, including small, medium and large schools, from inside and outside of Toowoomba City boundaries, and from the target audience of primary schools. Permission notes and sample letters are included in the appendices at the end of this thesis. A partial selection of schools was made from a list of schools that were indicated by systems available to participate ensuring where possible a selection of small, medium and large population schools, from Catholic and State systems, and from urban and rural settings.

Teachers that interact with children in the primary school and possibly use tools and materials included the classroom teacher, physical education specialists, (as tool use is mentioned as part of physical education section of the early year's curriculum, (Queensland Studies Authority, 2006), music specialists, (especially as they may set an assignment task of constructing a musical instrument), makerspace and art specialists. Some of these teachers may introduce and use specific tools such as hammers. To ascertain as many tools and materials that are introduced and accessed by primary school children, all teachers in the identified schools were invited to participate. The Darling Downs South Western Education region contains many primary schools including public and religious schools, which formed the basis of the target population.

There is evidence to suggest that experience and gender of the teachers may have an influence in the selection and use of tools by teachers; "as the majority of teachers in the primary sector are women who do not feel competent in the field of technology, they tend to avoid teaching the subject" (Rasinen et al., 2009). So, gender information was also gathered on the survey form as indicated in Table 3. Here as with other sections of the survey teachers who did not wish to state or did not align with the choices offered were not required to make an entry.

Table 3

Demographic Information on Survey Form

Tool use in the Primary School is mentioned in various Australian Syllabi though not necessarily specifically by name. Please indicate what tools the children use and when they may use these tools. If you do not use tools in your classroom, please just indicate year level and return form. If you wish to make a comment, please do.				
No. School Children < 60 ☐ <100 ☐ <300 ☐ <500 ☐ >500 ☐	Year level taught ☐	Are you Male ☐ Female☐ Class s ☐	Years teaching ☐	Please tick which term children use tools in your classroom. Ad hoc - means use with particular activity though not planned for the development of tool use Planned - includes instruction in use, handling and safety. Never - means you don't use these tools with this class.

Further, many contemporary tools such as 3D printers and laser cutters need some instruction and skill development for teachers to be able to use efficiently and safely so a short query on professional development was included. Similarly, hand tools, battery operated tools, and electric tools may need teachers to be in-serviced for effective use. Teachers were asked to comment briefly on their experiences in learning about the use of tools, materials and adhesives, formally either at further education establishments or university, or informally as self-taught, to gain an overview of where teachers may have gained their knowledge and skills. With safety issues in the use of equipment at the forefront of primary school teachers' minds in interactions with children, teacher's perceptions of their safety capabilities were also investigated by a simple continua question as indicated below in Table 4.

Table 4

Professional Development of Teachers

Professional Development							
Training engaged with	Never	Self-Taught	Uni./TAFE	n last year	n last 5 years	5 years	Comment
Tools							
Materials							
Adhesive Methods							
Safety with Tools, Materials Adhesives							
Commercial Construction Kits							

The level of skill development would also impact on the levels of confidence that teachers feel in engaging tool use with children. As Tschannen-Moran & Hoy (2001, p. 791) indicated a teacher's self-efficacy is not necessarily uniform across all subjects or tasks and impacts upon their persistence and enthusiasm for specific activities.

Many commercial construction kits are becoming available for the primary school class that engage the use of tools and materials to initially construct and repair e.g. Lego Boost and Meccano Max Robot. One such kit 'Little Bits' offers in its activity booklets ideas for the classroom including the use of box cutters and hot glue guns.

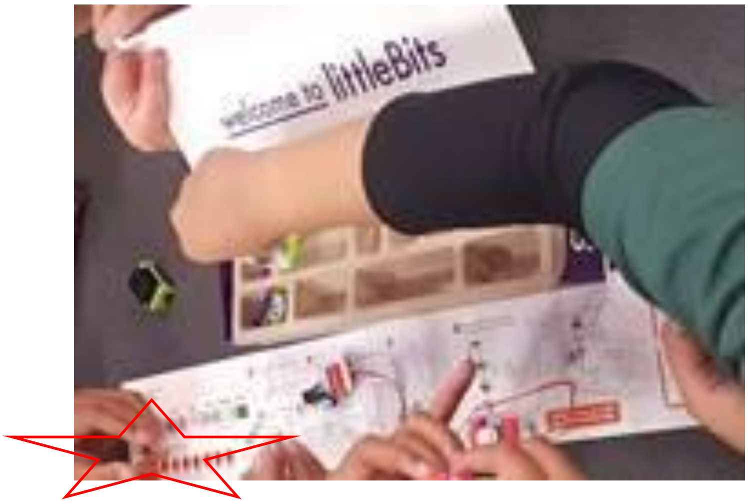

Figure 16. LittleBits kit with seven tools listed in the orange dots.

The specific tools are identified by the little orange circles (highlighted in red star) at the beginning of the activity, as shown in *Figure 16Figure 16*, and do not come with the kit. It is implicitly expected that the students have had instruction and access to these tools.

Table 5

Confidence of Teachers

Confidence in use of	Very low	Low	Average	High	Very high	Comment
Tools						
Materials						
Adhesive methods						
Safety						

In Table 5, the teachers responding to the survey were asked to indicate their own levels of confidence in using the tools, materials and adhesives in the survey list. The rating was self-determined by the responders, dependent upon how they perceived their confidence in their particular classroom and school situations. There was a small comment section for those teachers wishing to make a specific comment. A full version of the paper-based survey is presented Appendix 2.

3.5 Phase One

The research plan used was a sequential exploratory design using a cross sectional survey design, “where the researcher collects data at one point in time” (J. Creswell, 2012). This was taken by this researcher to mean that all the participants in phase one were asked to do the survey once at the same time. This does not mean all surveys completed at the exactly the same time, as in same hour, but they were completed within the same term of school year. Further, all surveys were hand delivered to individual schools by this researcher, and teachers were given opportunity to complete the surveys in the same meeting time space. Creswell (2012, p. 403) suggested an eight-step process for conducting survey research, and whilst this study focusses on mixed methods, steps four, five and six were relevant to consider within this section, including developing an instrument (step five) and administering the instrument (step six).

For the study it was hoped to get a representative sample response, as outlined in the initial confirmation document from over one hundred and twenty teachers across the seven years of primary school, from prep to year six. However, the positive response saw that one hundred and eighty surveys were returned, nevertheless eight of the returned surveys had no markings or indistinct markings that were unable to be used. This equated to a total number of individual teacher responses of one hundred and seventy-two useable surveys (N=172). These survey responses were able to be collated in groupings of teachers from prep to year two, year three and four, and finally from years five and six. The groupings allowed for many small school amalgamated classes as well as aligning with the Australian Curriculum. The Australian Curriculum(Australian Curriculum Assessment and Reporting Authority, 2018a) has bandings for several of its curriculum offerings for primary school including the arts and technologies learning area curricula. The bandings include prep (foundation) year level to year two (five to seven years old), years three and four (eight and nine years old), and years five and six (ten to twelve years old). There was a minimum of forty teachers in each year level grouping.

The range of schools included small, medium and large schools from across a variety of sectors, with size indicated by numbers of children in the school. This may be influential in that small rural schools are colloquially seen as utilizing hands-on resources and tools more than city schools, with agriculture and farming important in the Darling Downs region of Queensland.

In the survey there were many items listed with some that teachers may not know or be unsure of. To this end it was necessary to provide the teachers with explanations. Three ways were considered; first pictures of all the items, secondly definitions of all the items or thirdly attendance of the researcher at the survey location to answer any queries. The University of Southern Queensland Statistical Consulting Unit suggested the use of pictures or of actual items, especially of unusual items and if going to do the survey online or by mail. The inclusions of definitions of each item were similarly considered.

To have pictures of all the tools, materials and adhesives in the study would have increased the physical size of the survey enormously. An alternative was considered briefly where the number of tools, materials and adhesives were reduced to a few. However, without a benchmark it was difficult to identify which tools, materials and adhesives to use. The time required to peruse a large number of pictures and definitions was not deemed practical given the short response time required by participants as indicated to schools as being approximately fifteen minutes per survey. The third method of the researcher being at the distribution and collection of the surveys was deemed the best choice and was chosen. Hence the researcher was on hand to answer specific questions with verbal (explaining what a plier stapler was), some actual items (such as single hole punch) and some pictorial items on hand as required (such as fancy cut scissors).

Having the researcher present at the distribution of the survey was also seen as a way to provide the participants an opportunity to see the researcher and be able to identify with him as a teacher as well as a researcher, as well as seek answers to any general questions regarding the research. “It also gives the survey a human face” (Steele et al., 2001, p. 43). The ability to stay and answer questions whilst the surveys were completed also would have the advantage of a greater completed return (J. Creswell, 2012; Steele et al., 2001).

Approaching school staff as a whole to ask their support in completing the survey had several benefits. One was gaining systemic and principal approval to ask teachers to participate. Once the principal allowed the school to participate all the teachers were invited to participate in the survey which also had the greatest chance of gaining teacher responses from across the full range of year levels, if all the teachers in a particular school responded. Another benefit of visiting schools during staff meetings was the time spent collecting data was reduced by reducing the number of locations to collect data from. Sampling of the schools was achieved, after systemic approval, by contacting individual school principals within the southern Queensland education region directly, inviting them to participate. Monitoring which primary schools responded in the affirmative ensured support from schools across a range of sizes and locations. Another advantage of attending whilst participants were completing the survey form was that the return rate was higher. For those participants that wished to reflect on their responses further self-addressed envelopes were provided (Wiersma, 2005), though only three surveys were returned using this method.

The questions in the survey aimed to identify those tools, materials and adhesive methods children are using within their class. The tools, materials and adhesive methods were initially identified from a list selected from the literature and the curriculum documents. This list, whilst comprehensive, was not exhaustive but indicative. Teaching colleagues indicated that this method would be preferred, due to time available. They also indicated that, if the question was left open to write the tools used down, they may not think of all the tools they had used with children in a school year. Teachers were to employ a multiple-choice tick method to indicate their current usage with a choice of term and whether the usage includes skill development and safety considerations. There were to be limited opportunities for the participants to add different tools, materials and adhesives that they may have used. See sample survey in Appendix Two.

The survey questions were limited in physical extent to fit on one A3 sheet of paper, back to back, folded. This ensured that the data from an individual teacher was kept together and that the cost of the survey document was kept to a minimum, and this also meant that the generic questions of year level taught and gender of teacher for example were asked only once. The average amount of time spent on completing the survey by teachers was fifteen to twenty minutes as this was the amount of allocated time school principals allowed in their staff meetings for the survey to be completed. The collection time for all schools was planned to be conducted in term three or term four of the school year. The survey required teachers to indicate what tools, materials and adhesive methods they used with the children in their class during the whole school year. This timing was chosen to have allowed teachers to have engaged with their class in using tools materials and adhesives whilst having a good idea of what their plans were for using tools, materials and adhesives for the rest of the year.

It was planned to visit as many schools as possible within the same time frame. However, the access to teachers through the school principal was thwarted by several means. Permission to approach Catholic and State schools was a relatively unproblematic process of providing ethical and research clearances from the university and the study aims to the respective regional offices. Once this small hurdle was cleared the next was to access schools.

Here many of the school principals were supportive of the approach to conduct the study within their school, with some indicating they had never before been asked to participate in a research study. This said, there was a small but significant number who actively discouraged the surveying of their teachers, by acting as gatekeepers to accessing their teachers (Somekh & Lewin, 2011). They did this by not responding to telephone and email requests, or by leading-on the researcher with suggested times but then changing the selected dates and times. Finally, this continued until no suitable time or date could be established. In other instances, the office staff continually suggested that the principal was busy or away, gate-keepers for the gate keepers. On two occasions when contact was made with school principals by phone, the principal would the indicate what they saw was the best way to conduct a survey with their teachers and proceeded to state what the problems were with the suggested study survey format, finally indicating their school teachers would not want to complete this survey. Samples of the proposed survey document had been forwarded to school principals, along with the relevant ethical clearances. Others indicated that the lack of time for such things as research studies because their teachers were fully committed to the school and departmental imperatives that they could not possibly be asked to complete a fifteen-minute survey during a school staff meeting. Whilst these affected the data collection in some way, lost time, replanning visits, the biggest concern was not having enough responses from a range of primary schools as well as similar size schools to identify any valid patterns in the data collected on like schools.

There were many schools within the study area that had large populations of indigenous or multicultural clientele; indeed, in some schools this amounted to more than fifty percent of the student population. Whilst this may have had a cultural influence on the experiences with using tools as suggested by Alaezi (1988) it was not deemed necessary to identify race or cultural identity for this exploratory study, exploring what tools materials and adhesives were being used. It was not raised with in the comment section or in the phase two interviews; however, it could be followed up in subsequent research.

The data from phase one was collated into an Excel 2016 spreadsheet. All of the sample questions from the spreadsheet were tabulated in the columns and the individual responses became the rows. The data were scored and entered by the researcher, into the master sheet that contained all the entries from all the participants. To safeguard the anonymity of the participants school names and teacher names were omitted. Each survey form was assigned a number and allocated a row to enable checking that the data entries were correct.

To audit the accuracy, a colleague did a random sampling of ten percent of the survey forms and checked the data entered was accurate. In the master copy of the data there were approximately 450,000 individual cells. It was ascertained that there was less than one percent of error across all samples.

3.6 Phase two

The second phase of the study was to collect qualitative data using semi-structured interview questions that arose from the survey. Teachers felt that to be honest their responses had to be anonymous. This was stated on the participant permission slips and also reinforced in several interviews when queried by the participants “Is this between you and me?” There was a sense that some teachers felt there could be repercussions if they could be identified by their school principals.

To further assist in the anonymity of participants this researcher completed all the interviews and self-transcribed the audio. The results were then collated into a single Word document of one hundred and twenty pages. This meant that the end of one interview and the beginning of the next as well as school and year level of the school could not be aligned to a single teacher. When citing participants in this discussion the only reference to be given will be interview and page number as (Interview, p. 73).

Teachers from both Catholic and State schools were asked on return of the survey if they wished to participate further as a possible interviewee. The interview questions were developed from the survey and four teachers from each band level of school prep to year two, year three and four, and year five and six were interviewed. Teachers were interviewed at a time and location convenient for them and usually were at lunch time or afterschool sessions. Each of the interviews was conducted for a maximum of thirty minutes. Some teachers added to their verbal responses by email, which was added to the text of their interview.

The difficulties of interviewing teachers during school times was the interference of children asking for their teacher, assistance for unwrapping lunches, ringing of bells, administrative requests and other teachers. Only one interview was conducted per day. As indicated data from the interviews were recorded in one document then key repeating words were highlighted in different colours. These repeating words formed the basis of the emerging themes such as time, budget, safety, access and storage.

3.7 Phase three

Phase three was the analysis of all the data and is described in Chapters Four, through Nine. Data were listed and grouped by various methods to identify themes. The survey data were grouped into demographics, tools, materials and adhesive methods. Initial commentary from the survey was linked into broad themes. Initially data was grouped across all the data and then by the year level bands. Themes were identified using data that was grouped by patterns where repeating words on a printout were highlighted in different colours as shown in an Excel representation below by allocating a numerical value to each comment and grouping in the themes identified. The figure below is not generated directly by a graph inserted from Excel but rather it is a direct compilation of the comments and synonyms to a worksheet then merged and highlighted with corresponding colours. For example, the curriculum had specific subject areas such as the arts and technology as well as the C2C included.

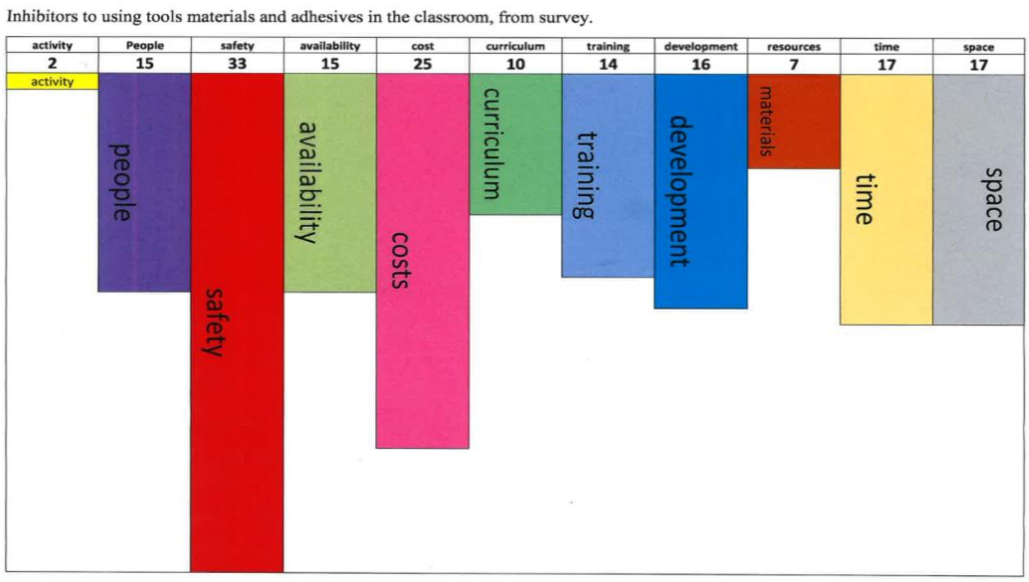

Figure 17 - Survey compilation in Excel

From this method the data was then presented in graphical form for discussion, with detailed mention of tools, materials and adhesive methods of specific note.

The interpretation of the entire analysis is followed by discussion of the combined overall results in Chapter Ten. Phase three shows the links between comments of teachers and the collated data in each of the research questions.

3.8 Chapter summary

The methodology chosen for this initial exploratory study was mixed methods and included quantitative data gathered by survey and a qualitative data collected via interview using semi-structured interviews. The staged data collections included a hand delivered and collected survey which was completed by one hundred and seventy-two individual teachers. An initial analysis of this data provided questions for the targeted semi-structured interviews. Survey data was entered into an Excel spreadsheet to be analysed and is presented in graphical form in the following chapters.

Chapter Four further elaborates on the data collected beginning with the demographic information. In relating to enablers and inhibitors to using tools, materials and adhesive methods it will highlight the year levels and commentary from teachers in the survey and tease out the themes.

4 Overview of all responses

4.1 Introduction

Chapter Four highlights the general information gleaned from the survey data, providing a background to the focus on the specific use of tools, materials and adhesive methods including year level. The demographic information is derived from both the open-ended questions allowing general comments, such as ‘please indicate enablers to using tools, materials and adhesives in your classroom’ and the specific demographic information relating to the closed questions such as ‘year level taught’.

The chapter develops with initial demographic information teachers and their experience. Comments from the survey were grouped and collated within the next sections of this chapter with a focus upon enablers and inhibitors to using tool, materials and adhesive methods in the primary classroom. The chapter finishes with activities that teachers feel engage students.

4.2 Demographic information

Schools were visited during school staff meeting times as arranged with the school principal and surveys were completed within that time. One of the advantages of conducting the survey during a whole school staff meeting was that all teachers involved with children were present. They also completed the survey within the 15 to 20 minutes allocated by the principal which meant that the number of teachers indicated was spread across the school year levels.

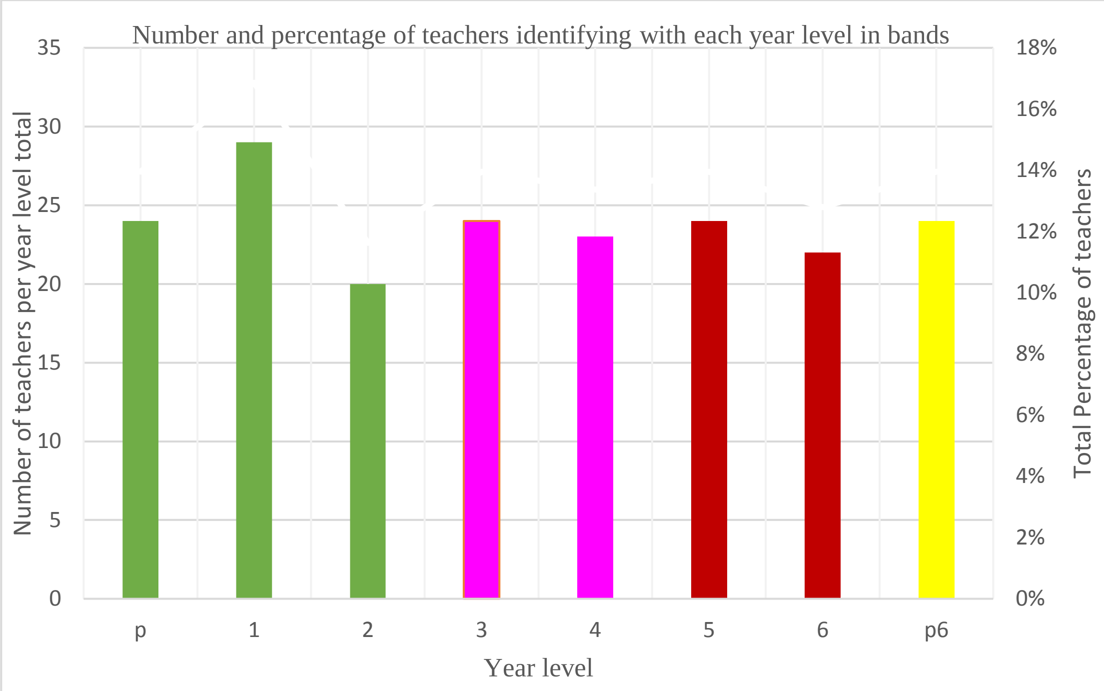

Figure 18. Number of teachers by year level shown in bands.

The number of teacher responses (N=172) used in this study have been collated by curriculum bands with specific year levels identified, as shown in *Figure 18*. Totalling the numbers of teachers in each column does not add to 172 because some teachers indicated that they taught multiple year levels, for example Prep and year 1, year three and four, or year five and six. The column of 'P6' teachers, in *Figure 18*, included the teachers who taught across all the year levels such as the support and specialist teachers (P6 number n=24). The colour groupings in *Figure 18* represent the year level bands, as in the Australian Curriculum for subjects such as the arts and technologies. The class teacher numbers of band one (prep to year two), shown as green bars in the graph totalled seventy-three (n=73), band two, years three and four are shown as pink (n=47), and band three, year levels five and six shown as brown (n=46). The number of teachers interviewed in phase two of the study was twelve (n=12) across all bands of schooling and included both State and Catholic school teachers. These numbers are indicative of a satisfactory sample of teachers for the study.

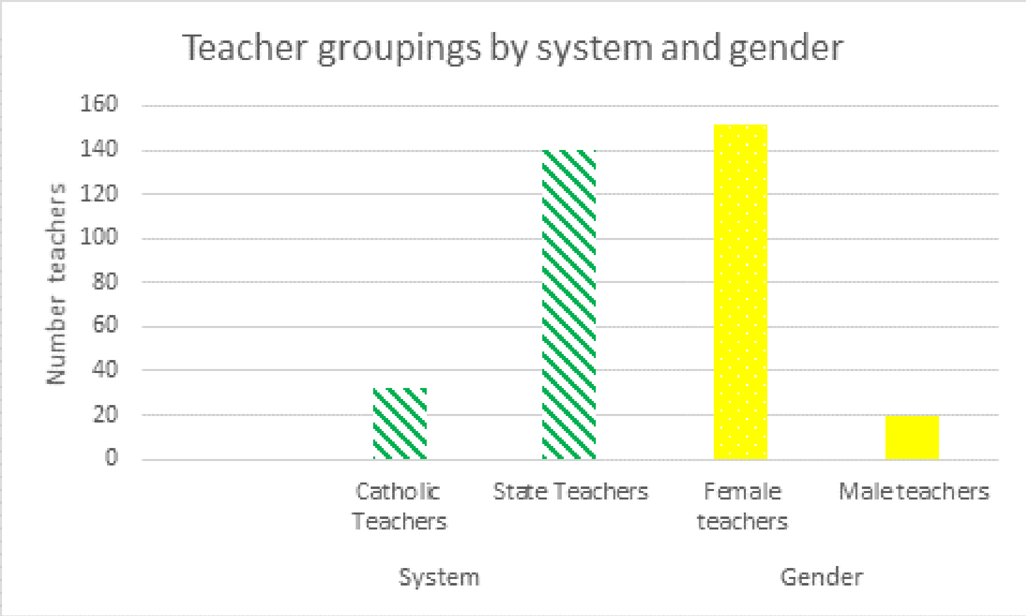

Figure 19. Teacher grouping by system and gender.

Figure 19 shows the distribution of all the teachers returning the survey forms teachers across the Catholic (n=32) which represents 8 percent of the teachers in the Toowoomba Diocese. State Systems (n=140) representing approximately 7 percent of teachers in the Darling Downs South West region, and the number of teachers identifying as either male (n=20) or female (n=152). According to Queensland College of Teachers (2016, p. 8) almost two thirds of teachers in Queensland teach in State schools. In 2017 the number of male teachers in the Catholic education system was 27% (Queensland Catholic Education Commission, 2017, p. 33) which is similar to the State Schools. In the Toowoomba Diocese the number of male teachers, extrapolated, as a percentage of all teachers is 25% (Queensland Catholic Education Commission, 2017, p. 33) The State average for the number of registered male teachers in 2015 was 24% and female teachers 76%, interestingly the predictions are that by 2025, only 20% will be male (Queensland College of Teachers, 2016).

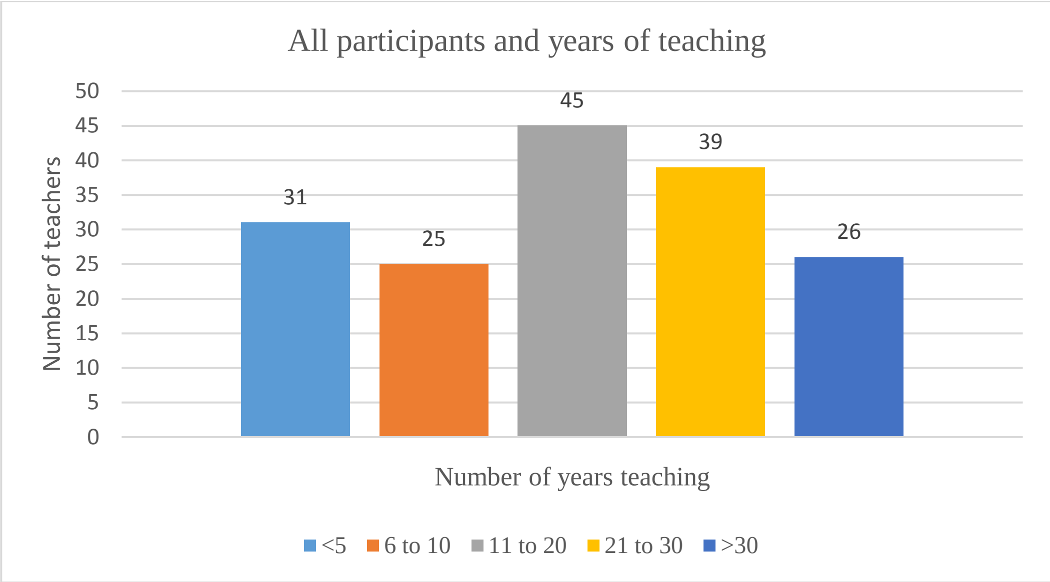

Figure 20. Number of years teaching.

indicates the number of teachers that identify with the number of years of teaching experience, across all the survey respondents. Three percent of participants having indicated no response. No reason was given on the survey form for the null response. Eighteen percent of teachers indicated less than five years of teaching experience and when compared to the Queensland college of teachers' statistics this would seem to be comparable to beginning teachers in the age range of 20 to 24 years of age which also indicated a similar total.

In the survey teachers were asked to indicate the size of school they were in and the results tabulated in *Figure 21*. The size of school that teachers were in was also considered and schools were banded into groups by size delineated by this researcher. Schools over five hundred students were largest, with schools having less than sixty children were the smallest. No primary schools in in the region had over nine hundred students with the larger state primary schools having between 650 to 850 children with the smallest schools having about twenty students. The responses indicated a broad cross section of size of schools and reflected that there were more teachers in larger schools, as was to be expected, even though there were similar numbers of schools in each banding.

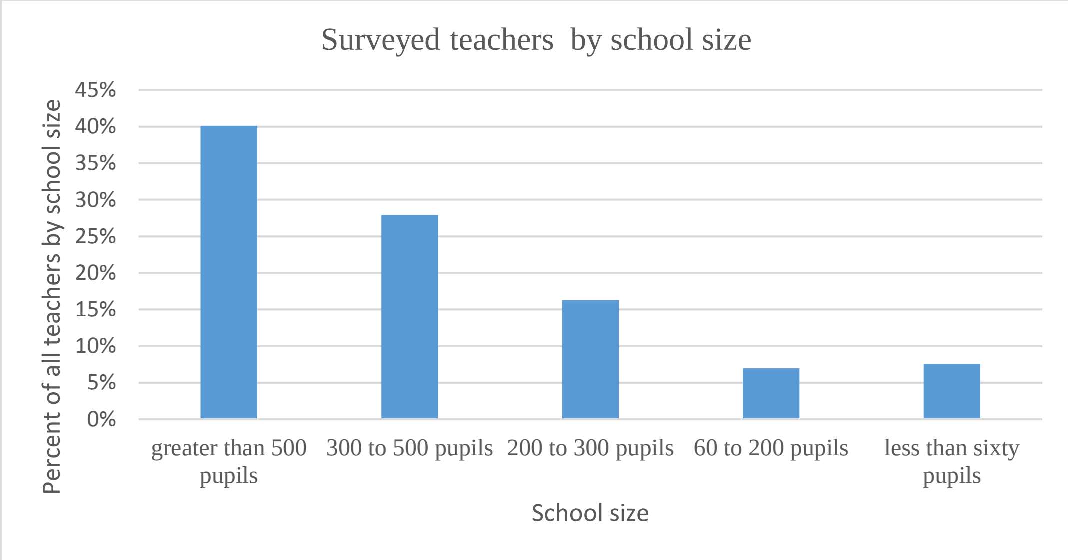

Figure 21. Survey results of teachers by school size.

Figure 22 indicates the training teachers have had in the use of tools, materials, adhesives, safety, and commercial kits with an indication of recency. Training experiences at university or tertiary and further education (TAFE) were indicated, and recency of skill development of teachers as being within the last twelve months, up to five years or above five years. Ninety-two percent of teachers indicate that they have not had formal instruction in the use of tools, which may indicate a reason for the lack of diversity in the use of tool, with 54% percent of teachers surveyed saying they have never had instruction in the use of tools or are self-taught (thirty eight percent), which may be an indicator of why more recent tools such as laser etchers and 3D printers are not being used. A similar figure occurs in the use of materials with 91% either having no formal training (49%) or are self-taught (42%). Adhesives are at 93%, (51%) never having had formal training and (42%) self-taught. This raises the questions about understanding the of work place health and safety issues including the use of material safety data sheets.

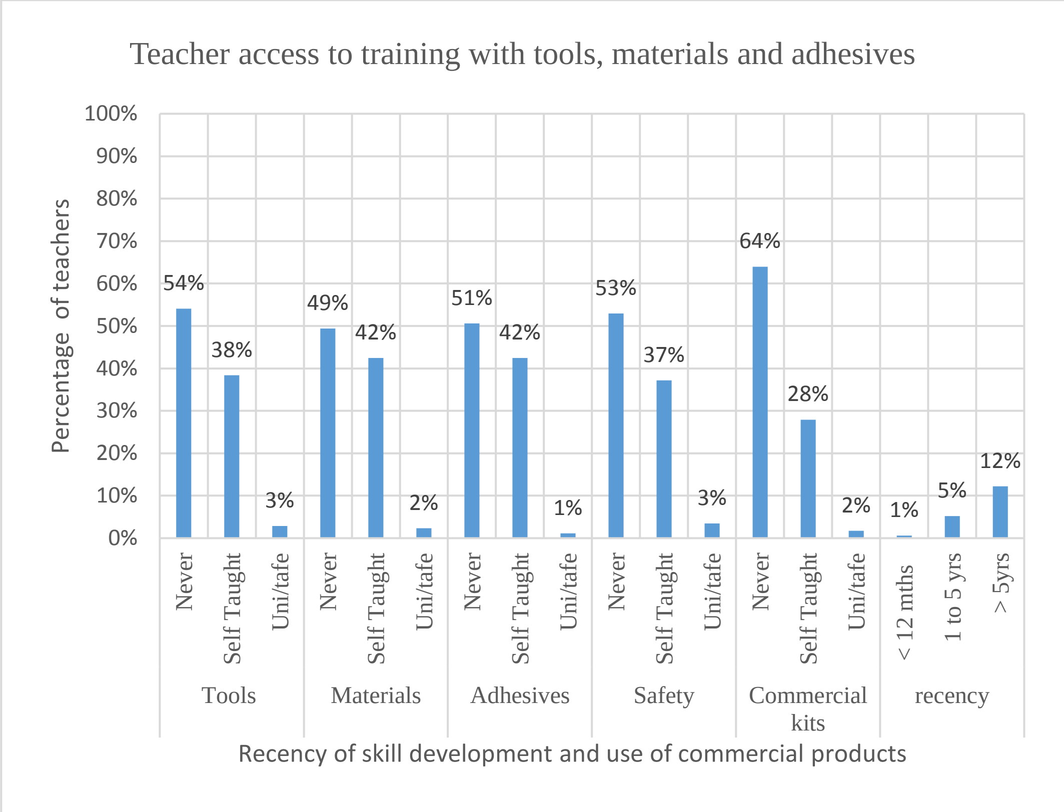

Figure 22. Teacher access to training including skill development.

In safety training 53% of teachers indicate they have never had training and 37% self-taught. This survey does not distinguish between self-taught with guidance from experts or by self-exploratory and learning by mistakes. This has ramifications for doing risk assessments and using material safety data sheets, and possibly for not using tools, materials and adhesives.

Commercial kits, such as construction kits of Lego or K'nexs and electronic kits such as Littlebits, Arduino, Makey makey and Raspberry Pi, are becoming more popular at school science, technology, engineering and mathematics activities as part of curriculum STEM initiatives, and yet sixty four percent of teachers say they have never had any training in the use of commercial kits. These kits often are used to value add to products made in the classroom. Examples of this may include a cardboard robot with blinking lights controlled by an Arduino controller which activates when someone approaches. Tools such as scissors and hole punches are used in the construction of the robot and connecting the Arduino controller mat require the use of pliers and soldering irons.

Of those teachers that have completed some training across all areas listed, twelve percent indicate that their skill development was completed more than five years ago, five percent between twelve months and five years, and only one percent within the last twelve months.

"Honestly, my professional development here is pretty pathetic to be quite honest, I don't have, I haven't had any professional development to be really honest when I look at it I haven't learnt anything actual." (Interview p73).

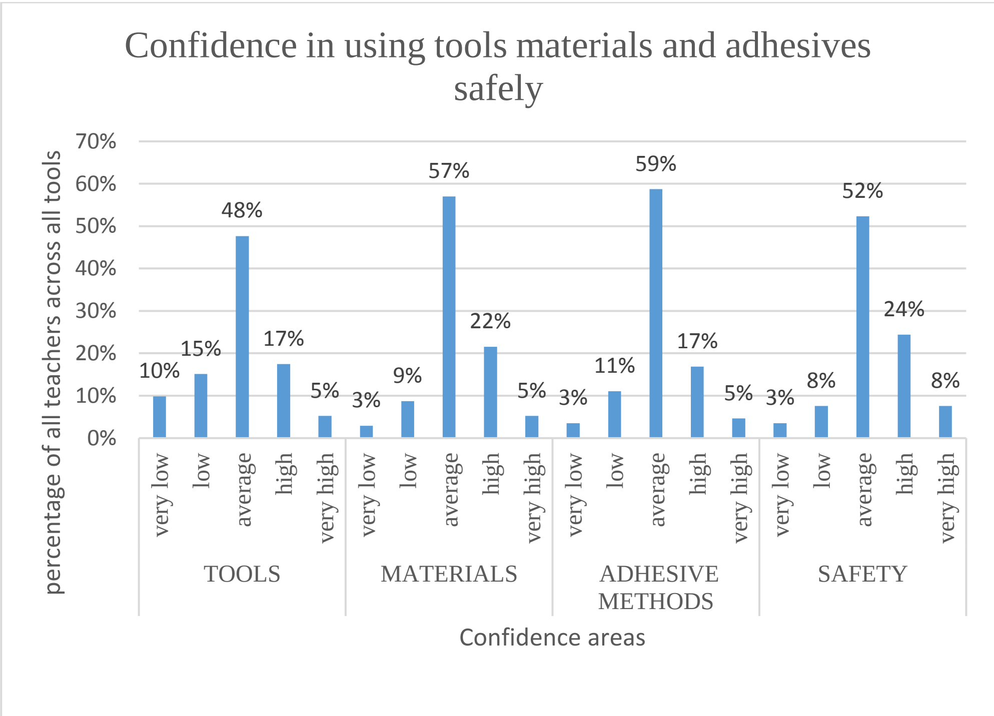

Figure 23. Confidence in using tools, materials and adhesives safely.

Figure 23 indicates the teacher's confidence (self-determined) in using tools, materials and adhesives and the results centre around the average. A quarter of teachers (twenty five percent) indicated that they had low (15%) to very low (10%) self confidence in using tools. This contrasts with the 12% indicating low and very low in the use of materials, and the 14% in the use of adhesives. Some materials may be used as received by the class teacher and not manipulated or transformed with the use of tools such as A4 card, paddle pop sticks, and hessian. It may also indicate pre-cut and prepared kit materials for making such objects as card buses which have been pre-cut out and pre-creased with slots for tabs to hold together.

Safety confidence comparisons show 76% of teachers have average to high confidence in safety with very low (n=6) three percent, and very high (n=13) eight percent safety confidence.

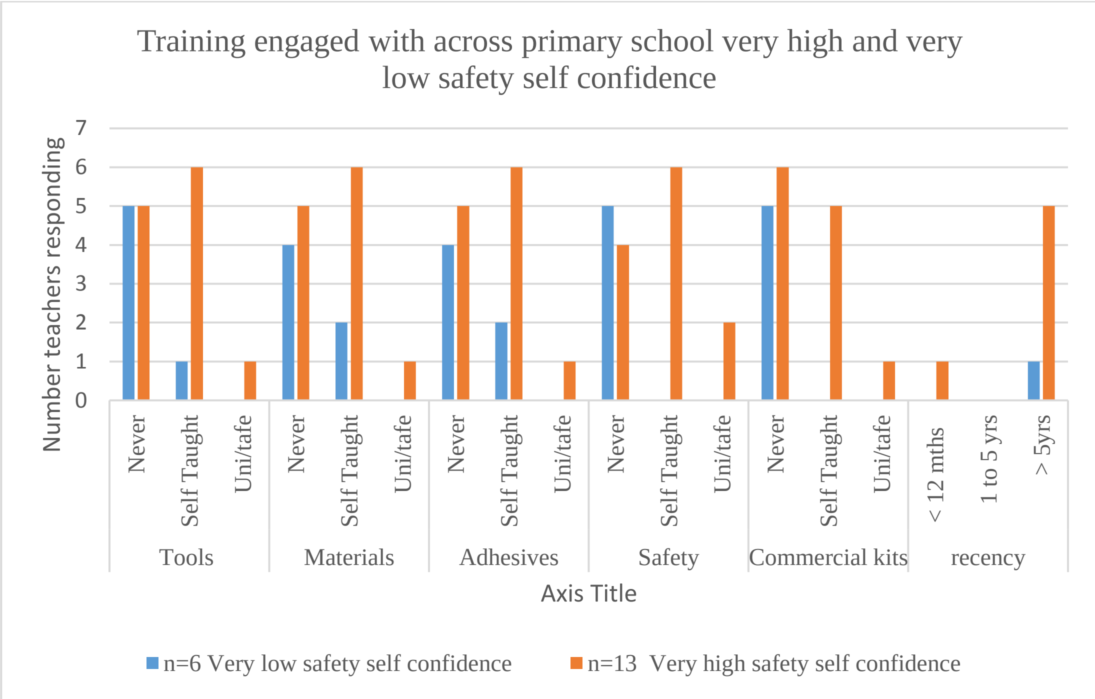

Figure 24. Teacher access by very high and very low safety self-confidence.

Teachers that presented at either end of the continuum of a very high self-confidence or a very low self-confidence in safety are shown in *Figure 24*. Those that had a very high self-confidence indicated that they had self-taught more so than never, with one teacher indicating some training at university or TAFE; except for commercial kits where fifty percent of very confident teachers indicated that they had never had instruction in commercial kits.

Teachers that presented with a very low self-confidence had higher percentages stating that they had never had any training compared to self-taught with no teachers indicating that they had university or TAFE training of any sort.

> While all jurisdictions require professional learning to align to the Australian Professional Standards for Teachers, there is no national requirement for teachers of STEM subjects to undertake specified hours of professional learning in discipline specific content and pedagogy delivered by

an accredited provider such as a university, TAFE or other registered training providers. (Education Council, 2018, p. 15)

Further, no teachers with low safety self-confidence indicated that they had had training in either safety nor commercial kits.

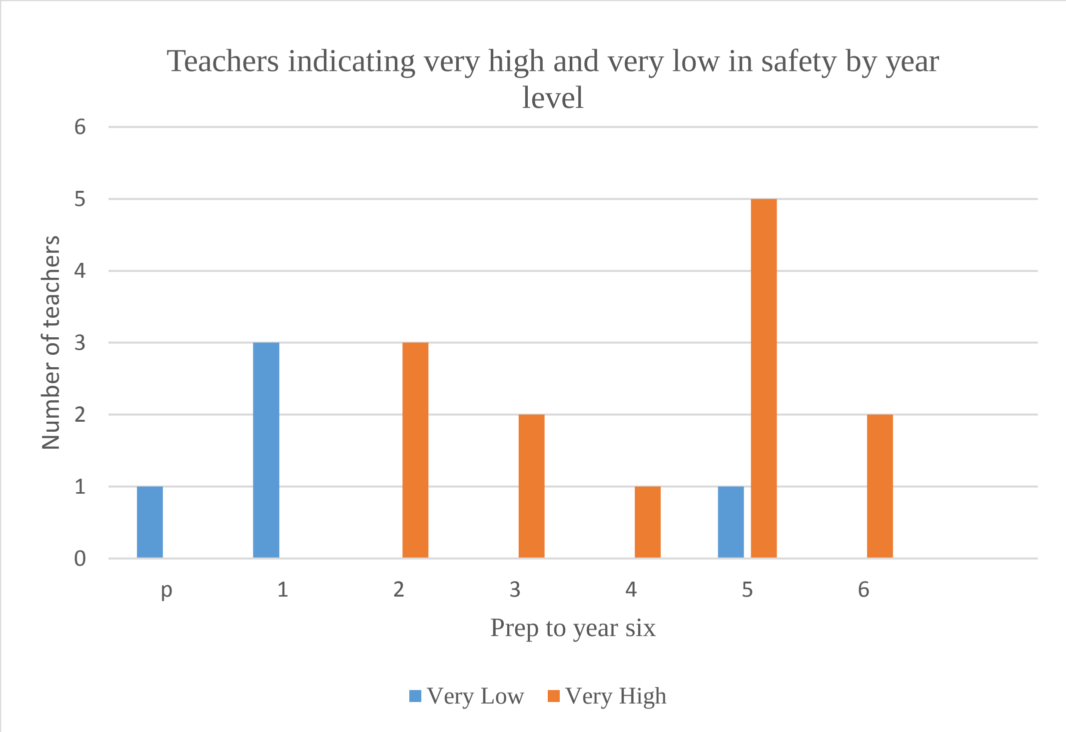

Figure 25. Teachers indicating very high and very low in safety by year level.

Figure 25 shows that teachers in the foundation and year one area are more likely to have a very low confidence in their perceived safety of tools than those in year five and six. Whilst there is a decrease from year two to year four with those teachers with a very high confidence in the use of tools, materials and adhesives.

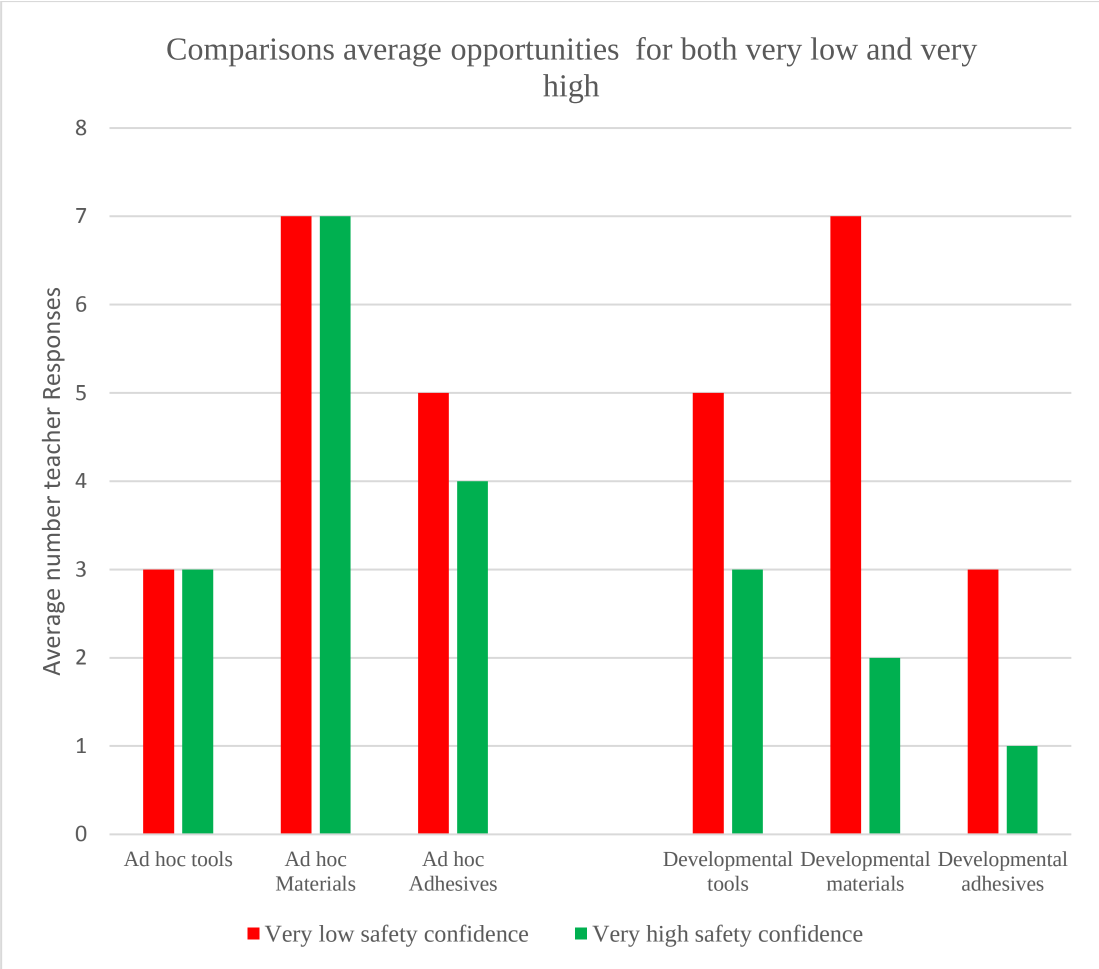

Figure 26. Average opportunities for very low and very high from high/low safety confidence.

Figure 26 shows a comparison between the average number of opportunities teachers provided in class by teachers that identified as very high safety confidence and very low safety confidence in using tools, materials and adhesive methods both in an ad hoc manner or in a developmental manner. The comparisons between ad hoc use showed remarkable similarity between very low and very high confidence levels of teachers, with tools and materials having the same number of responses, on average.

The developmental comparison was very different. Very low self-confident teachers were twice as likely to provide developmental instruction opportunities overall on average, and in each individual category. This may be due to the teachers feeling less confident in children using tools and thereby compensating by providing more instruction and could be a possible future study. Developmental opportunities in the use of tools were provided in three tools by very high safety confidence teachers and from the tabulated data, these opportunities rose mostly from mathematical skills. In the use of adhesive methods these teachers, that recorded very high self-confidence, only indicated one opportunity to provide developmental instruction.

4.3 Initial comments from the survey

Over one half of the teacher respondents (n=116) surveyed answered with remarks in the comments section of the survey on the back page. The comment section allowed teachers an initial opportunity to suggest affordances, that is the enablers or hindrances, in the opportunities for children to use materials, tools and adhesives. The percentage of teachers responding to each of the headings are shown in *Figure 27*.

The introduction to the comment section indicated that there were many factors influencing the use of tools, materials and adhesives in the primary school classroom. Mindful of the time factor in the completion of the survey, some suggestions were offered as possible ideas including materials, teacher beliefs, safety, storage, space, time, accessibility, teacher confidence and experience. The responses in each section were based upon broad questions regarding a) enablers and inhibitors, b) what teachers would like to use and c) what support that they would need to allow that to happen.

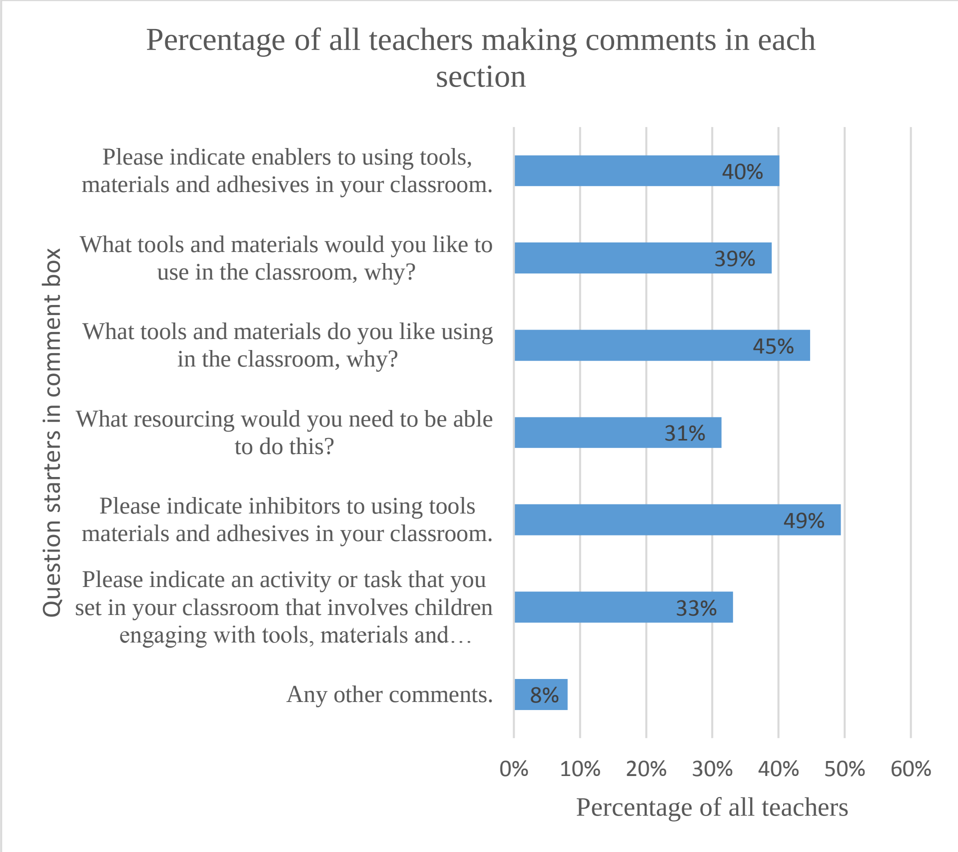

Figure 27. Percentage of all teachers making comments in each comment section.

Not all teachers responded in each of the comment boxes, rather they commented quickly in sections that most correlated to their thoughts at the time. Therefore, whilst sixty seven percent of teachers overall wrote at least one comment they did not comment on every open-ended question.

The comment section of the survey allowed for some compilation of ideas but also provided some individual insights to the issues highlighted in the survey. These individual comments were deemed by the researcher, to be important statements in their own right, and when cited in the text of this thesis are cited and referenced by the line number of the master Excel spreadsheet as (Response 51). Reference to specific cells in the spreadsheet are determined by the comment section column heading from which the response is taken.

Table 6 Sample Responses Indicating Training from the Survey

Enablers to using tools, materials and adhesive methods in the classroom	**Response line number**
• step by step instruction on application and implementation and safety	8
• training to use tools in a primary situation would be beneficial, especially in the areas of safety and creativity	13
• prior access, use	50
• teacher expertise	51
• knowledge of tools and tool use	72
• If I know how to use the tools, materials, and adhesives	162

Teachers provided a range of ideas in response to the survey question 'Please indicate enablers to using tools, materials and adhesives in your classroom,' that have been collated. These collations are based upon interpretation of the comments by the researcher that most linked the ideas listed, for example in the sample from the 'Training' grouping the word training only specifically occurs once, yet the highlighted words indicate the understanding of training. There was considerable overlap of each sub area as in Response 13 which alluded to safety and creativity as well as training as shown in the Table 6. The response line number refers to the line in the master collated Excel master spreadsheet.

4.4 Enablers to using tools and materials

Responses in the section on enablers to using tools, materials and adhesives were grouped together under the following headings; curriculum, training, safety, time money, access and child development.

In ‘Curriculum’ teachers indicated that the ability to integrate curriculum with creative ideas that engaged children’s interest was most useful. Integration of curriculum highlighted the integration (Response 154) of such discipline areas of the arts, science, technology and mathematics (Response 46) along with pedagogy of teaching both explicitly (Response 34) and creatively (Response 143) that matched the scope and sequence of the curriculum (Response 19). The use of language to identify specific concepts was also mentioned (Responses 144,164) and that teachers were amenable to using tools to teach the curriculum, “I would use tools that are required to teach the curriculum, access safety etc” (Response 9).

Training encompassed both the teacher’s training as well as the children’s training. Child training included previous experience from previous school year levels and prior experience from other sources such as home. “Kids (some) already know how to use some tools and materials etc (Response 16), and “needs to be explicitly taught in prep (Response 36).” Other responses in the enabling section of training of teachers were found in Response 8, 13, 50, 51, 53, 72, and 162. Some teachers indicated that they had training outside of professional development in education as they came from industry such as a chef or manual arts. One teacher indicated that they “have taught manual arts courses (Response 53).” Overall the sense was “training to use tools in a primary situation would be beneficial, especially in the areas of safety and creativity” (Response 13).

Safety was a big consideration for enabling in the primary classroom with respondents indicating the need for activities with risk assessments. These ranged from “things that are easy, don't require risk assessments, and are readily available” (Response 18) through to safety by age of child. For example, “safety, age of students, access to tools” (Response 64). There was also an indication that some schools did not feel that the student’s behaviour and knowledge would allow the use of tools because it would be “unsafe with most children at this school, little knowledge” (Response 54).

Time was indicated as enabler by some teachers specifically and others with the need to have support as well as links to the curriculum. (Responses 35, 68). “I would use tools that are required to teach the curriculum” (Response 89, 48), “Time” (Responses 28, 86, 89, 114)

Budget, money and costs were mentioned in Responses that covered such reusable items as 3D printers, (Response 48) and other tools, to consumable items, “budget funding to purchase materials, (Response 47)” as long as they were “cost effective” (Response 160).

The largest themed grouping of responses was those grouped under accessibility. These Responses included the need for space and ease of access to the tools and materials as well as the availability of resources in the community. (Responses 22, 23, 24, 27, 36, 62, 49, 52, 58, 81, 101, 124, 161, 91). These Responses to access also indicated that there was a need for space, storage, ease of access, availability of tools, materials and adhesives.

The final theme was related to child development (Responses 35,41,64, 74, 110, 123, 171). This grouping alluded to the age and maturity of the child as well as the links to hand-eye coordination and fine motor skills.

The teachers noted that costs and budget were important, and some indicated that they provided resources. This was not delved into with all the interviewees unless they specifically raised the issue when talking about providing resources for the curriculum. For example, from (Interview P. 86) regarding fund raising;

Teacher (T). Okay so they are selling to raise money

Interviewer (I) For

T. The chaplaincy programme whereas any other money that is raised from the art show is to top up the art budget

I. Right so the money you mentioned before that’s what the school puts in and then the top up goes on top of that?

T. That’s what should happen in theory

I. So, what happens in practice

T. Well what happened in practice this year was I know we raised twelve hundred dollars last year and that money has become our art budget

I. So, the school actually by default is not putting anything extra into

T. Not this year (Broadly, $1200 for this school equates to $300 dollars per term for the whole school which then equates to approximately $1 per child per term or 10 cents per week.)

4.5 What tools and materials would you like to use in the classroom, why?

Teachers had a great range of suggestions for the tools and materials that they would like to engage with in the classroom with many reasons that were directed at reengaging children in the learning process. Some of the efforts were directed at the need to engage with new and novel products that are readily available but not in schools; “familiar is blah” (Response 4).

Tools and materials were seen as important for actively engaging children in the learning process as well as part of the child’s growth in physical development. Tools and materials could be incorporated into classroom activities for effective learning (Response 62). The support for children’s learning included using craft for fine motor skill development (Response 8, 34, 35, 102). The development of practical skills (Response 41, 72, 74) and cross curricula general capabilities.

The use of tools and materials were seen as a possible way of reengaging boys (Responses 43,44), those children with autistic spectrum disorders (Response 85) and therapy for others, “all types of craft and disposable materials for art, therapeutic for kids, helps them learn through cementing information/ fine motor development, creative for brain development” (Response 102).

The tools, adhesives and materials that were suggested by teachers that they would like to use ranged from everyday resources to hammers and nails. These tools and materials could be broadly grouped to suit particular requirements. Art tools such as lino cutters (Response 23) and craft materials and tools (Response 8, 34,35). Construction tools and materials including wood, hammers and nails (Responses 9, 36, 42, 43, 50, 52, 99, 164). Science, maths, technology and mechanical tools and materials were included in responses that included using electrical and electronic components (Responses 164, 123, 159, 99, 68, 141). Sewing machines and sewing implements, hot glue and materials such as hessian and fabric (Responses 16, 21, 52, 112, 118).

All of these could align with the curriculum and with the development of the whole child, “woodwork, we have hands on kids and whilst low in literacy they would benefit from a feeling of success” (Response 62). Further all children would benefit from the development of practical skills (Response 13).

4.6 What tools and materials do teachers like using?

Many teachers in this section listed several of their favourite tools, materials and adhesives including glue, scissors, card board, paper, paint; sponges wire, aluminium foil, wood, wood glue, acetate glue and hot glue (Responses 7,10,12,19,49,50,64). A few teachers indicated electrically operated tools such as jigsaw and 3D printers (Response 119, 124). There was a sense that these related to life skills (Response 79, 80) though there was a sense that teachers were needing to supplement the tools and materials students had previously had in the home, “the basics for home use, as experience in handling tools is not frequently taught (split families etc) (cooking utensils, hammer, pliers, screwdrivers, clamps)” (Response 163, 164).

Teacher skills and confidence also came to the fore with teachers using tools they were confident with (Response 26) including sewing implements though some teachers indicated that they only used tools and materials that were basic as they were not crafty (Response 54). This was further developed by the response that suggested that children did not actually use the tools and materials suggested, rather “the teacher or teacher aide uses the tools on behalf of the kids” (Response 62).

Many of the suggested tools, materials and adhesives were related to curriculum. Arts and craft were listed by many teachers as separate to each other. Crafts included wood working (Response 87) and sewing. The Arts had the most curriculum Responses (Responses 24, 66, 169, 40, 41, 98) whilst mathematics had the least (Responses 20, 123, 160) though the cutting and measuring (Response 160) were implicit in several other responses. Other curriculum areas included technology (Responses 66, 113, 158), science (Responses 129, 46) As one teacher response shows “I like it when students are involved in technology tasks and a variety of different tools and materials are required. Gives a chance to show kids different materials and tools” (Response 158), and adhesives such as PVA, acetate and hot glue (Response 154).

Hands-on and fine motor development (Responses 14, 22, 35, 157) were also cited in this section of the comments with a sense of the development of the use of tools over the primary school. Interest for the child was indicated (Response 128) along with the need for the “basics for the lower grades” (Response 21), including scissors and glue with the children. Children needed to use these tools and materials independently, unsupervised and safely (Responses 49, 146, 155), and with the ability to easily access and clean up (Responses 113, 163, 17) at the completion of the activity or day. As the tools have been learnt, so they move to independence, though they need to be "developmentally appropriate to enable children to use them" (Response 172).

4.7 Resourcing

Teachers indicated some ideas that would enable their children to participate more fully in using tools materials and adhesive methods. Two main areas emerged in the comment section professional development and training and funding. Professional development included ideas sharing, people and training for teachers, teacher aides and students. (Responses 4,16,18,29,50, 54, 7, 119, 124, 68, 158, 163).

Funding raised issues such as school budget for larger items, curriculum budgets, class area budgets and budget allocations to individual teachers (Responses 6, 10, 12, 18, 22, 23, 24, 34, 46, 80, 81, 155, 91, 98). The sense with the allocation of budgets to classes and teachers was to allow for the teachers to best decide what consumable resources were needed and when.

Allocation of support from teacher aides was also raised in this section with the need for extra assistance to be given when engaging with tools, materials or adhesives, being available to assist in setup, collation of materials and clean up (Responses 26, 35, 41, 85, 68, 107, 112, 129, 154). This may include supporting small group work and students with special needs and safety (Responses 129, 112)

4.8 Inhibitors to using tools, materials and adhesives in the classroom

Inhibitors were defined as those barriers to teachers that stopped or limited opportunities in engaging children with constructing and manipulating the materials with tools. Teacher confidence and student ability came to the fore in this section. Children of various levels of capability in the everyday classroom including those with special needs, lack of fine and gross motor control, maturity and age of children (Responses 7, 10, 21, 33, 40,60, 62, 72, 89, 93, 122), "most things need to be explicitly taught and children have limited exposure to use pencils and scissors correctly" (Response 95).

The limited exposure is reflected in time comments (Responses 2, 3, 6, 15, 26, 38 117, 123, 141, 156) as is the amount of time to plan and collect resources then access tools (Response 22). Access to resources including tools, materials and people are also indicated in the comments (Responses 4, 25, 26, 56, 57, 68) with some suggesting the need for specialised spaces (Responses 68). Time to clean up (Response 85), time to train (Responses 47, 52, 64, 78),

Safety concerns were high on the list of inhibitors including (Responses 25, 48, 49, 38, 55, 59, 62, 85, 92, 96) behaviour of students and risk assessments (Responses 7, 11, 16, 24). These comments were often linked to the availability of up-skilling and professional development for all staff (Responses 16, 18, 29, 50, 54) and summed up in “Safety issues, supervision- lack of teacher aides to do some activities, time to do more hands-on activities” (Response 165).

4.9 Activities engaging children in the use of tools, materials and adhesives in the primary class

This section asked teachers if they had specific activities that actively encouraged children to use tools and materials in their classroom. Many of the suggested activities were curriculum related. Design activities in technology included such products as three pig’s home, balloon cars, water cooler, balsa boat, wind power vehicle, building boats, carry bags and mouse trap racers (Responses 22, 35, 41, 62, 124, 155). Arts and craft had sewing craft, papier Mache, string art, decorating instruments and commercial crat kits (Responses 17,20,46,54,158, 91). Using glue sticks in literacy to glue sheets into books, attach phonic letters to match images, literacy groups cut and paste activities, and gluing in activities (Responses 68, 74, 98, 109, 111, 112). Maths and science activities included making a clock, board games, science measuring activities, simple circuits, some maths activities (Responses 9, 19, 58, 72, 128, 146). Other activities included making Mother’s and Father’s Day presents (Responses 94, 119). Some of the activities allowed for students to consider sustainability by recycling materials from home that the children bring on the day of the activity.

4.10 Chapter summary

The comment section of the survey form was to allow teachers to voice their ideas across a continuum of suggested ideas. The first section identified the demographics of the study participants. This was followed by the participants ideas for enablers to using tools, materials and adhesives in their classrooms followed by queries as to what they would like to use in their classroom. The third sections asked what tools, materials and adhesives they liked using in their classrooms followed by a query as to what resourcing they would need to enable that to occur. The fifth section asked to provide reasons that inhibited the use of tools, materials and adhesives in the classroom. A final section asked what activities that they engaged children within the classroom that allowed for the use of tools, materials and adhesives.

Teachers acknowledged that training and development of skills were important in the comments, however the suppositions were a concern. Teachers made statements that said “I teach year X so safety is a factor in not using tools, materials or adhesives” (Response 110); students have “little experience or knowledge of (tools materials or adhesives)” (Response 122); experience and background of the student including prior knowledge (Response 71) and “most things have to be explicitly taught and children have limited exposure to use pencils and scissors correctly” (Response 95). Whilst all these statements are indicative of teacher’s views, they also show that there is a belief that the tools and materials need to be introduced and skills developed before the year level activity that requires them. Therefore, it can be surmised the teacher does not feel responsible for introducing tools, materials, and adhesives to the children in a safe and efficient manner allowing them to developmentally become more able to use them in a wide range of further activities. Administrative teams both at the system and school level reinforce this by not supporting effective professional development for teachers and aides. It is interesting to note that in the analysis of the use of tools section nearly five percent of teachers indicated that they did not use any of the listed tools, and a further analysis of the possible reasons will be considered.

Chapter five will specifically look at the data from the survey that relates to the use of tools. It will identify groupings of tools and when they are introduced both by year level and by term.

5 Tools

5.1 Introduction

The development of tool use in the primary school is related to materials and adhesives used in activities across the curriculum. As such it is expected that tools would be identified in the general capabilities of the Australian Curriculum that includes recognition of the developmental needs of the students. The range of tools used in the primary school is many and varied and is complex to analyse as each of the commonly named tools have several sub groups with different specific names that are grouped under a common name such as scissors. For example, a quick internet search of educational scissors identifies that there are many specific names and groups of scissors, some of which are commercial names and others that are trade linked such as sewing scissors, hairdressing scissors and electrician scissors. Disability services also discusses a range of modified scissors including loop scissors, dual control scissors and table top scissors (Child and Youth Services, N.D., p. 3). Hammers are another example that are generically grouped and include any hammers students may have come across including ball peen, claw, tack or mallet hammers.

Naming of some tools was problematic because of different names for similar tools and because of space within the survey, tools were named by a common understanding of similar tools such as scalpel being a knife with a single, small, sharp blade and this also encapsulated those tools sometimes called craft knives. In American studies craft knives are often referred to by the brand name Exacto knives. Understanding of safety scissors was also difficult because a common understanding is not articulated, with easily accessible supermarket stores having safety scissors as blunt, and unable to cut anything but paper. These types of scissors are then bought by schools and education institutions that cause frustration to the students and teachers because they fail to do the task they were purchased for, general all-purpose classroom scissors. Similarly, surgical scissors were used to encompass all scissors that had sharp or non-rounded points, and safety scissors being delineated by having rounded ends.

Table 7

List of Tools on Study Survey

Safety scissors	Surgical scissors	Fancy cut scissors	Pinking shears	Guillotine
Double hole punch paper	Single hole punch paper	Leather punch	Hand drill	Circle (compass) cutter
Ruler	Tape measure	Maths Compass	Dividers	Protractor
Rotary trimmer	Stanley knives	Box cutter/ razor knife	Scalpels	Lino cutters
Fret saws	Tenon saws	Hack saws, metal saw	Hammer	
Electric scroll saw	Electric jig saw	Laser cutters	Electric drill	Dremel type tool
Side cutters	Wire strippers/ cutters	Long-nose pliers	Snub-nose pliers	Paint roller
Awl	Sewing needle	Tweezers	Clamps	Varnish paint brush
Multi grips	Spanners	Phillips screw driver	Flat blade screw driver	Water colour paint brush

All tools identified in the survey are shown in Table 7. They were grouped to make analysis more manageable and on the survey sheet, the list of tools was broadly grouped on the survey form to assist teachers in identifying the tool. The five broad headings were cutting tools including knives and saws; hole-making including punches and drills; electrical tools including Dremel type tools; art tools including brushes; and measuring tools including rulers and tape measures. However, a more refined grouping was developed for the analysis. Within the rest of this chapter tools are grouped by similar tool types- for example double blade tools were those that used two cutting surfaces and included scissors, shears and guillotines. Single blade tools included knives, scalpels and trimmers. These tool groups are shown in the section headings.

Some tools had the capacity to fit in multiple groupings for example electric drills could align with the hole making group or electrical tools group. To avoid duplication and confusion tools were only allocated to one group that best represented the data. For example, the electric drill was shown in the electric tools group and not in the hole making group as electricity was the main power source. Wire tools were those most associated with manipulating wire used in the primary school in art and science and for making simple electrical circuits, including pliers and side cutters. Side cutters could have been included in the double blade group.

The tools could also have been allocated to groups dependent on physical skill set needed to operate. Single hole punch, side cutters, pliers, shears and scissors could all be represented in a group that included single hand grip tools with a scissors type grip using similar muscle groups. However, for the purposes of this initial exploratory study, the focus is more on what tools are being used and the groups are aligned for ease of identifying patterns of use. In some figures, the number of tools materials and adhesive methods the null responses were left in the diagrams to highlight the lack of opportunities of children to engage with them.

5.2 Double blade cutter tools

Figure 28 shows double bladed tools including those that have two blades and a pivot point that brings them together to cut the desired materials. Scissors are the most common type of cutting tool used in the primary school.

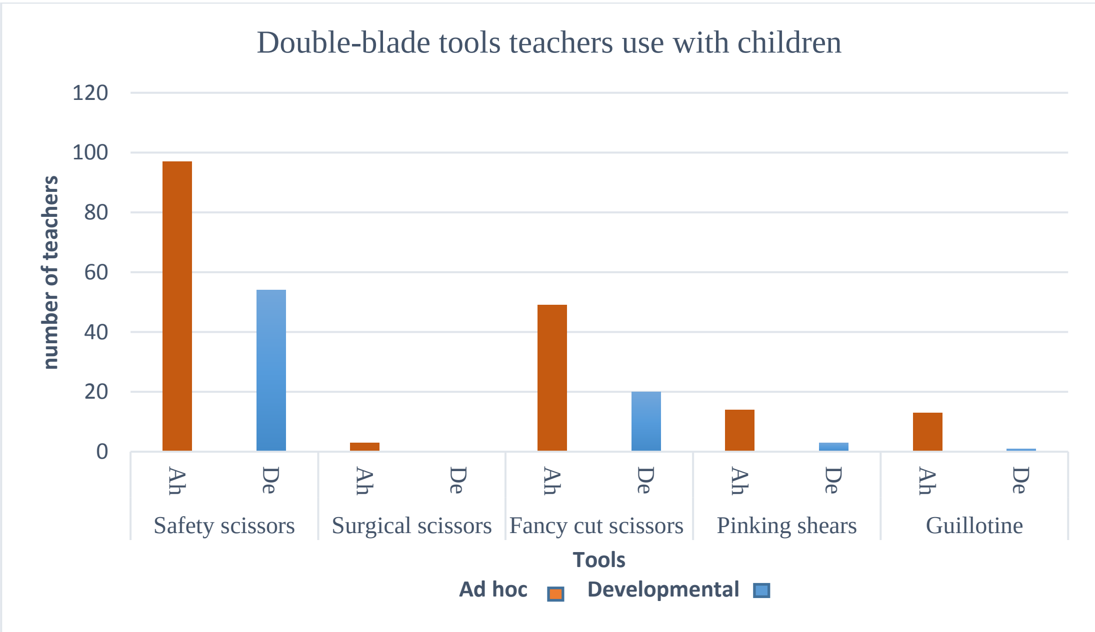

Figure 28. Double-blade tools teachers use with children.

Out of the total respondents to the survey, ninety-seven teachers (56%) indicate that they allow the use of safety scissors with children in an ad hoc manner, and fifty-four teachers (31%) indicating they provide instruction to students in the safe use of scissors. *Figure 28* reflects that the most used double blade tool is safety scissor followed by fancy cut scissors.

5.3 Single blade cutter tools

These tools, *Figure 29*, are those that include knives, and which have only one cutting blade. Rotary trimmers used in schools are usually those on a cutting track with the blade enclosed, whereas other types of rotary cutters that may be used include pizza cutter styles with the blade exposed.

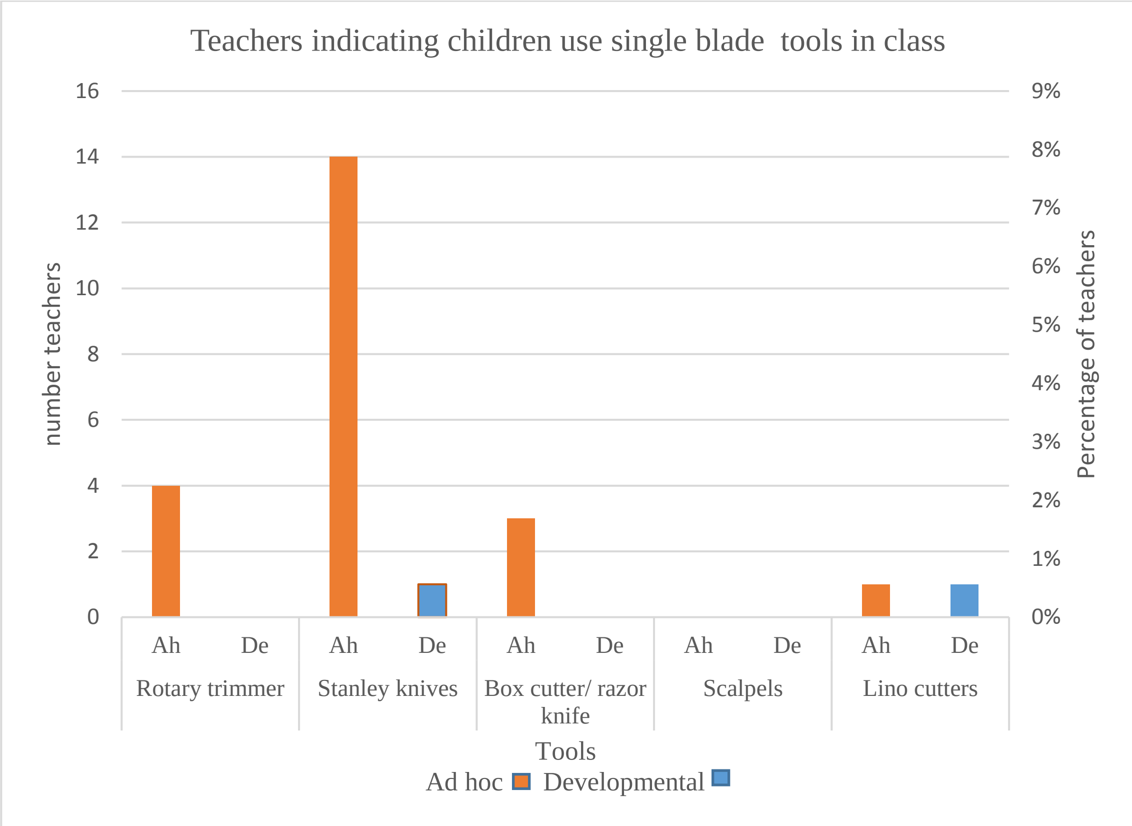

Figure 29. Teachers indicating children using single blade tools in class.

Figure 29 indicates the graphical representation of the single blades, with two vertical axes, number of teachers and percentage of teachers. This has been done to show that whilst Stanley knives are the most used fourteen responses (total number of teachers), they are in fact only used by eight percent of total respondents (percentage of teachers). Teachers generally are not using single blade cutters of any sort with children and the instruction their use is only indicated by one teacher in the use of Stanley knives and one in the use of lino cutters. The lack of safe handling of knives including identifying the cutting edge was highlighted in the introductory chapter. Plastic knives are used because of safety but interestingly some teachers are using them as a time saver, “I think it is safety probably and I can throw a plastic knife in the bin …so I don’t have to wash it up” (Interview p. 43). The use of a rotary cutter (ad hoc 4), as a trimming tool with a covered inaccessible blade, was expected to be used more in the primary school than the guillotine (ad hoc 13) but this was not the case. It may be that the lack of instruction in tools means that teachers are unaware of the rotary cutter as an alternative to the guillotine.

5.4 Hole making tools

These tools include double hole and single hole hand punches for paper and thin card that have a hole approximately six millimetres in diameter. Double hole punch are usually desktop punches and single hole punches are usually hand held. Single hole punches could also include leather punches with various hole sizes and special character punches. Hand drills using a geared handle and circle cutters using a blade tip have the capacity for varying diameters. These are shown in *Figure 30*.

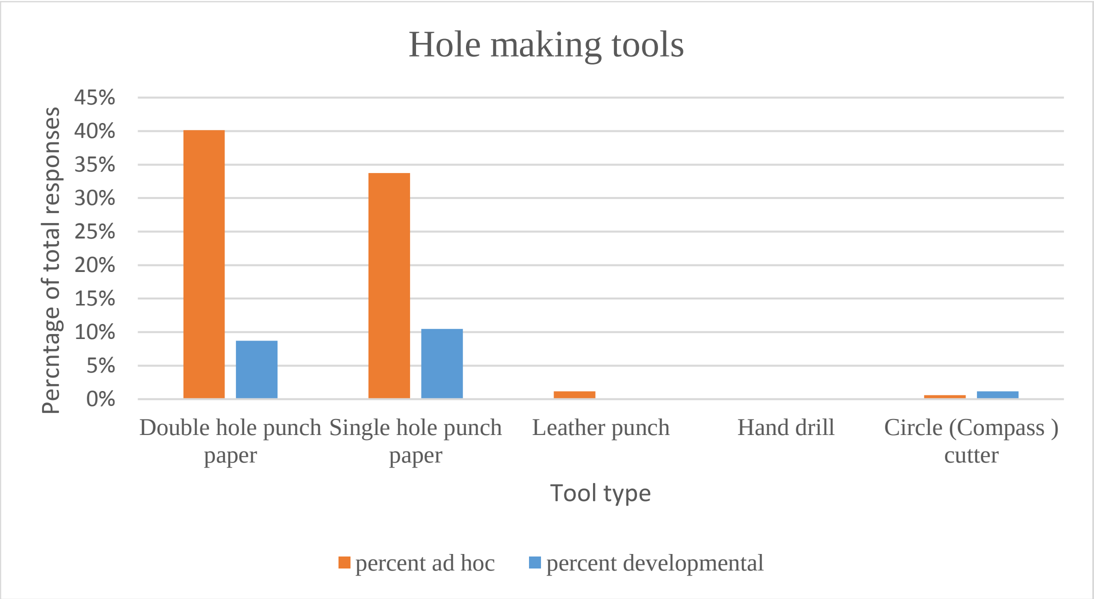

Figure 30. Hole making tools.

Desktop double hole punches are the most common hole making tool with forty percent of teachers indicating that they use them with children in an ad hoc way, with nine percent indicating that they provide students with instruction in their use. This instruction may include how the double hole table punch operates compared to the single hole punch. These are followed by single hole punch with

34% of respondents providing ad hoc opportunities for students to use and ten percent indicating that they provide instruction in the use of the tools. Only 1% of teachers indicated any use of leather hole punches and circle cutters either in ad hoc or developmental ways. No teachers indicated that their students used hand drills in either an ad hoc way or developmentally. The lack of use of latter tools may be indicative of the lack of use of different materials indicated in chapter six.

5.5 Manipulative tools

Manipulative tools are those that require a complex twisting or holding method to operate effectively. They are shown below in Figure 31

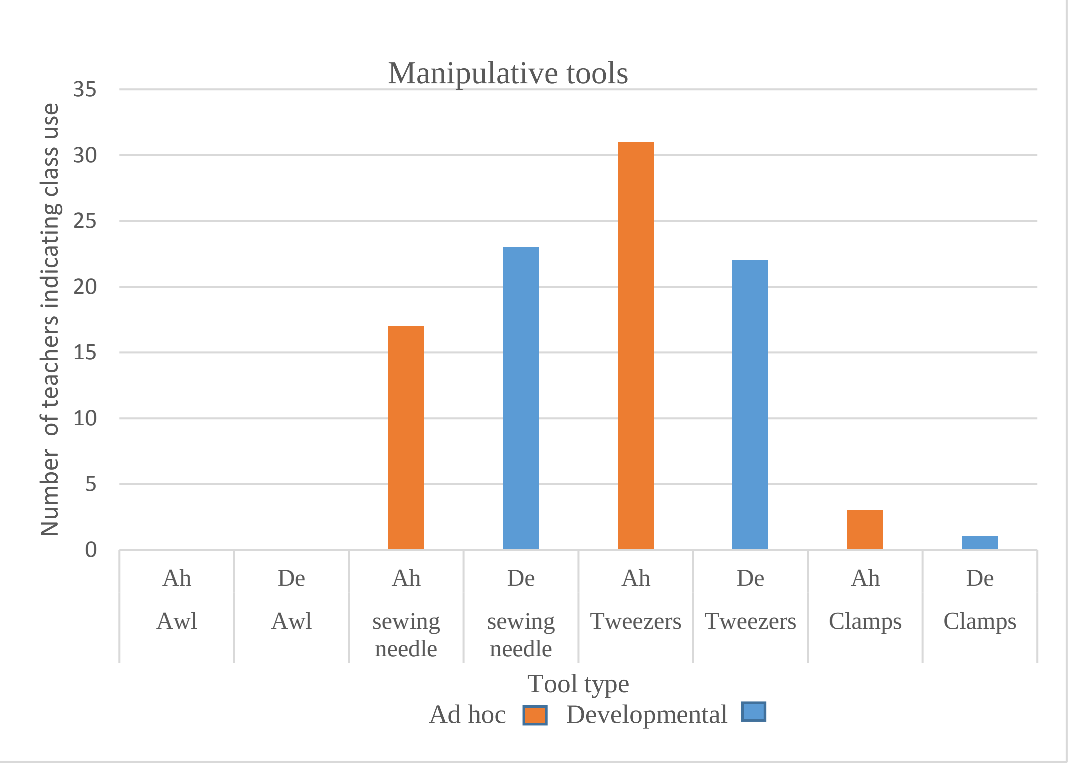

Figure 31. Manipulative tools total.

Manipulative tools shown in Figure 31 require some manipulation by the child to be effective. Awls for example require a twisting motion, needles threading, pushing and sewing motions, and tweezers a gripping and hold and release motion. Awls are useful for pushing holes through stiff though not solid materials such as canvas and felt, and some plastics. In prep they have been used to push holes through corrugated cardboard to allow ties to be used. They could also be used to centre another tool such as a hand drill in medium density fibre board (MDF). Tweezers in the early years assist with the development of fine motor skill and strength (Interview P1) and become more specialised in the upper years as a science tool for manipulating specimens.

Not one teacher indicated the use of an awl and less than two percent of teachers indicated that the children used clamps in their classroom. Tweezers were the main tool of use in this category with thirty-one teachers indicated that they used the tools with children in an ad hoc way whilst twenty-three indicated that they provided structured lessons to the children in the use of tweezers.

5.6 Mathematical equipment tools

Mathematical equipment tools were grouped based upon mathematical measurement tools as indicated in Figure 32. These are the measurement tools identified by classroom teachers as being used in the primary classroom.

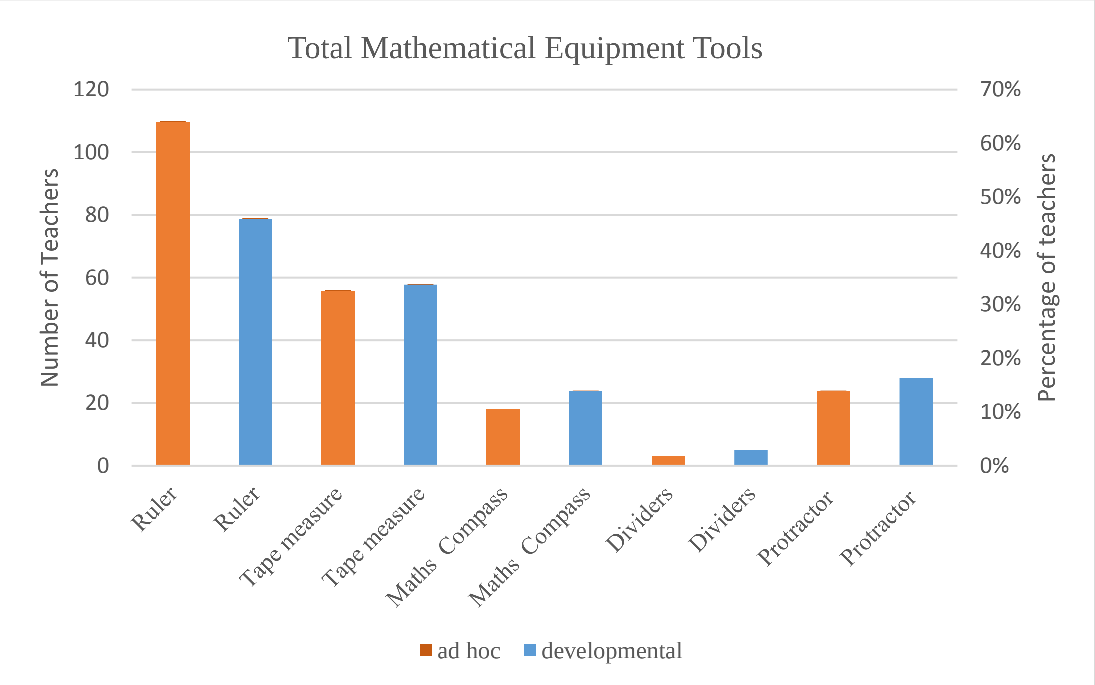

Figure 32. Total mathematical equipment tools.

Mathematical equipment tools data was grouped based upon mathematical measurement tools as indicated in Figure 32. Mathematical rulers were indicated teachers to be used by one hundred and ten teachers (64%) in an ad hoc manner and by seventy-four teachers (46%) in an instructional, developmental manner. Overall the mathematical tools grouping showed more alignment with developmental instruction and allowing students ad hoc use, for example with the use of maths compass ten teachers in year five provided developmental instruction and five provided ad hoc opportunities. Further analysis of the data showed that two year five teachers provided ad hoc opportunities without indicating any developmental opportunities whereas six teachers indicated developmental instruction without any ad hoc opportunities. Tape measures were used by similar numbers of teachers in providing ad hoc opportunities (33%) and developmental instruction (34%). Maths compass and protractors were instructed to students by 14% of teachers with fewer teachers, 10%, providing ad hoc opportunities to use. Similar results were found with the protractor with 14% indicating ad hoc use and 16% indicating instruction in the developmental use of the protractor.

5.7 Art tools

Visual arts provide opportunities in the primary classroom for multiple uses of a variety of tools. Within this section the listing of tools is specifically paint related. Other tools that maybe used, such as hot glue guns, are identified elsewhere within the study.

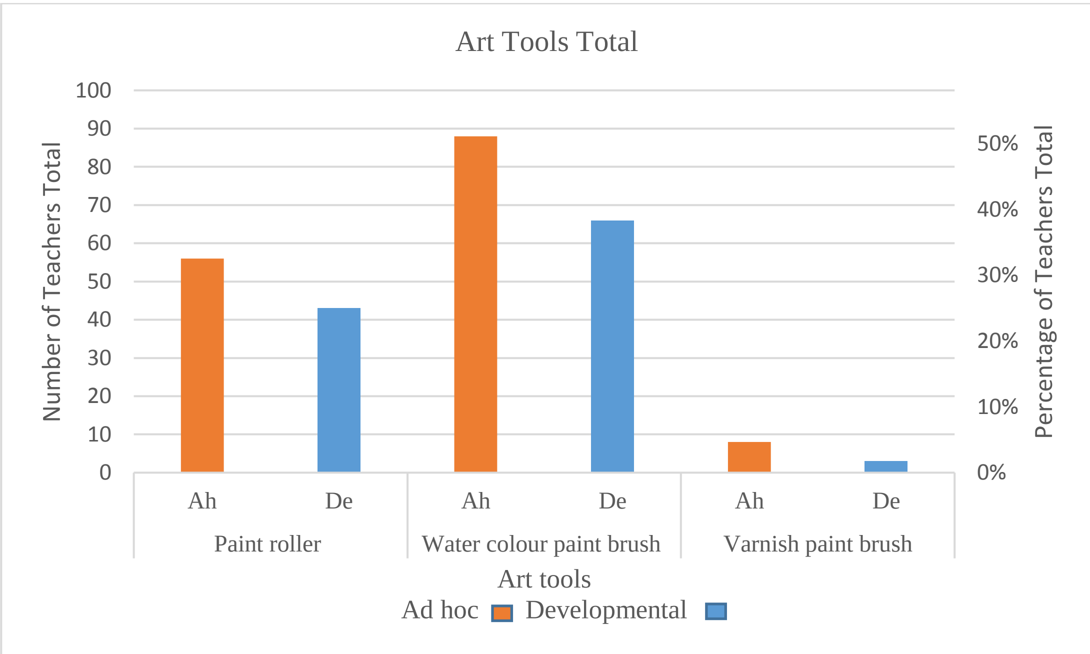

Figure 33. Ad hoc and developmentally used art tools

Whilst acknowledging the arts refers to a broad section of the curriculum encompassing visual arts, drama, music, media and dance, within the art tools section were mostly those that concerned applying paint or other fluid materials such as ink or glue with results in *Figure 33*. Paint rollers were used by 33% of teachers in an ad hoc way with 25% of teachers indicating that they provided instruction to the students in the use of these tools. Paint rollers were developmentally introduced by 75% of teachers in band one, that is 16 prep, 10 year one and 6 year two teachers. Similarly, whilst water colour brushes were used by 51% of respondents indicating that they provided ad hoc opportunities for students to use and 38% provided instructions in their use in the prep to year two band 60% of teachers indicated that they provided developmental instruction.

5.8 Electrical Tools

Electricity is a major part of everyday lives for children from birth. In classrooms children engage with many digital technologies that use electric power. For this study the focus is on hand held manipulative tools as indicated below.

Table 8

Total Electrical Tool Use Across Primary School

Electrical tools	Ad hoc		Developmental	
	Number	percentage	number	percentage
Electric scroll saw	0	0%	0	0%
Electric jig saw	0	0%	0	0%
Laser cutters	0	0%	0	0%
Electric drill	0	0%	0	0%
Dremel type tool	0	0%	0	0%

Electrical tools, Table 8, encompassed all tools that used electrical power to operate including mains and battery power. Dremel tools are commercial group of handheld electrical craft tools and is the common name for similar craft tools now available. Listed in this group were the emerging tools of 3D printers and laser etchers and cutters. No teachers indicated that they used any of the electrical tools in the list with children, in either an ad hoc manner or in an instructional developmental way, hence there is no graph. Besides training a year five teacher summed up reasons for avoiding electrical tools as “safety, safety issues” including “we don’t have the right ratio of students to teachers (Interview p. 46). Hot glue guns are listed in the adhesives section of this study.

5.9 Saws

The list of saws in this study are those that this researcher has used in primary schools throughout his career. The saws are often associated with carpentry as is the hammer.

Table 9

Total Saw Use in Primary School

Saws	Ad hoc		Developmental	
	number	percentage	number	Percentage
Fret Saws	0	0%	0	0%
Tenon Saws	0	0%	0	0%
Hack saws,	2	1%	0	0%
Hammer	9	5%	9	5%

The list of saws in this study are those that this researcher has used in primary schools throughout his career. The saws are often associated with carpentry as is the hammer.

Table 9 shows that saws are not a priority in the primary classroom with only one percent of teachers indicating that they use hacksaws across the primary school with children in an ad hoc manner. This would make it difficult to alter sizes of wood, tubing, some metals and plastics. All other saws were not used in either an ad hoc manner nor developmentally. There was also no instruction in the use of the hack saw.

Hammers did not fit within other groups for the purposes of this study. Students did not use fret saws or tenon saws in any manner according to the respondents. One percent of teachers used hack saws in an ad hoc way with students but without instruction, as indicated by the zero response in the developmental column. Five percent of teachers indicated that they used hammers with students in both a developmental way as well as providing ad hoc opportunities. An interviewed teacher indicated “you would have to have nails or screws or something like that and there in comes the risk factor having issues with children having hammers, or screws and screw drivers and things like that” (Interview p.57). One teacher stated that

> We used to do things like carpentry and that in the old preschool, carpentry table and things like that skills and saws, all those things but they are pretty well packed away in the shed now because we don’t have time for that kind of thing, we don’t really get outside that often, really once they do their gross motor skills. (Interview p.2)

The lack of the use of saws in the tools section would be an indicator that wood and other firm materials such as Perspex would unlikely be used in the materials section and that nails and screws would also be minimally used.

5.10 Workshop tools

Workshop tools included those commonly found in workshops and sometimes in sets of similar types but different sizes such as screwdrivers and spanners. Spanners included small open and closed types.

Table 10

Workshop Tools Across the Primary School

Workshop Tools	Ad hoc Percentage	Developmental percentage
Multi grips	0%	0%
Spanners	1%	0%
Phillips screwdrivers	4%	1%
Flat blade screwdrivers	3%	0%

There was no instructional use of these tools except for one teacher indicating the use of Philips head screwdrivers, in Table 10. Ad hoc use of multi grips (zero percent), spanners (one percent), Phillips head screw drivers (four percent) and flat blade screw drivers (three percent) was not graphed, one interviewed teacher lamented, “you know it was as much about the tools as fine motor use for screwing lids and nuts and bolts but they (carpentry tools) also drew them in. (Interview p. 15).

The lack of instruction in these tools would indicate an unlikely use in the construction and deconstruction activities of electronics, basic electricity and robotics.

5.11 Tools used in the making of electric circuits

Electrical circuit tools group Table 11 were so named in that they are associated with students making electrical circuits and cutting wire though they could also be used in other areas such as arts in making wire structures. Wire strippers included those with thickness setters as well as fixed cutting blades. It would also be expected that these tools would be more likely introduced to children in years five and six as the science curriculum refers to using circuits. The curriculum into the classroom (C2C) when elaborating on the resources required to teach the Design and Technologies curriculum states, “ where more specialised resources are required, there is usually alignment to a C2C unit for another learning area/ subject for which schools should already have the equipment for example, electric circuits in year six science” (Department of Education Training and Employment, 2016b, p. 3).

Table 11

Total Electrical Circuit Tools in Primary School.

Electrical circuit tools	Ad hoc	Developmental
Side cutters	1%	0%
Wire strippers/ cutters	1%	1%
Long-nose pliers	5%	0%
Snub-nose pliers	2%	0%

Wire strippers, useful in the construction of simple electrical circuits were the only tool in this group where any teachers provided instruction (1%) to students though there was some ad hoc use of side cutters (1%), wire strippers (1%) long nose pliers (5%) and snub nose pliers (2%). Pliers are also useful in forming metal plate by bending, *Figure 34*, as shown in the shaping professional development resource from Queensland curriculum and assessment authority (Department of Education and Training, 2015b). One teacher in the year three four band indicated that they used wire cutters and strippers in a developmental way in term four for art.

Figure 34. Using Pliers to Bend.
QCAA PowerPoint (Department of Education and Training, 2015b)

5.12 Tools by Year Level

In identifying how tools are developed across the school year, a comparison of tools by year level is made as in Figure 35. Tools are grouped by year level and by bands as per the Australian Curriculum. Prep to year two, year three and four, and years five and six, are the bands associated with the primary school curriculum. The trends of most of these tools across the primary years from prep to year six was a decline in use, as in the examples of safety scissors and paint rollers.

Each teacher responding to the survey indicated whether they used tools in a developmental (De) and Ad hoc (Ah) manner or both, followed by which term they used the tools, and finally the curriculum area that the activity the tools are most used with (MASTO – Mathematics, Arts, Science, Technology or Other).

To identify and collate the data the tools data was organised by year level then a formula was applied in Excel to add the total number of teachers indicating each tool to gain a percentage. Therefore, a hundred percent in a table represents only those teachers in the band not a hundred percent of the teachers responding to the survey.

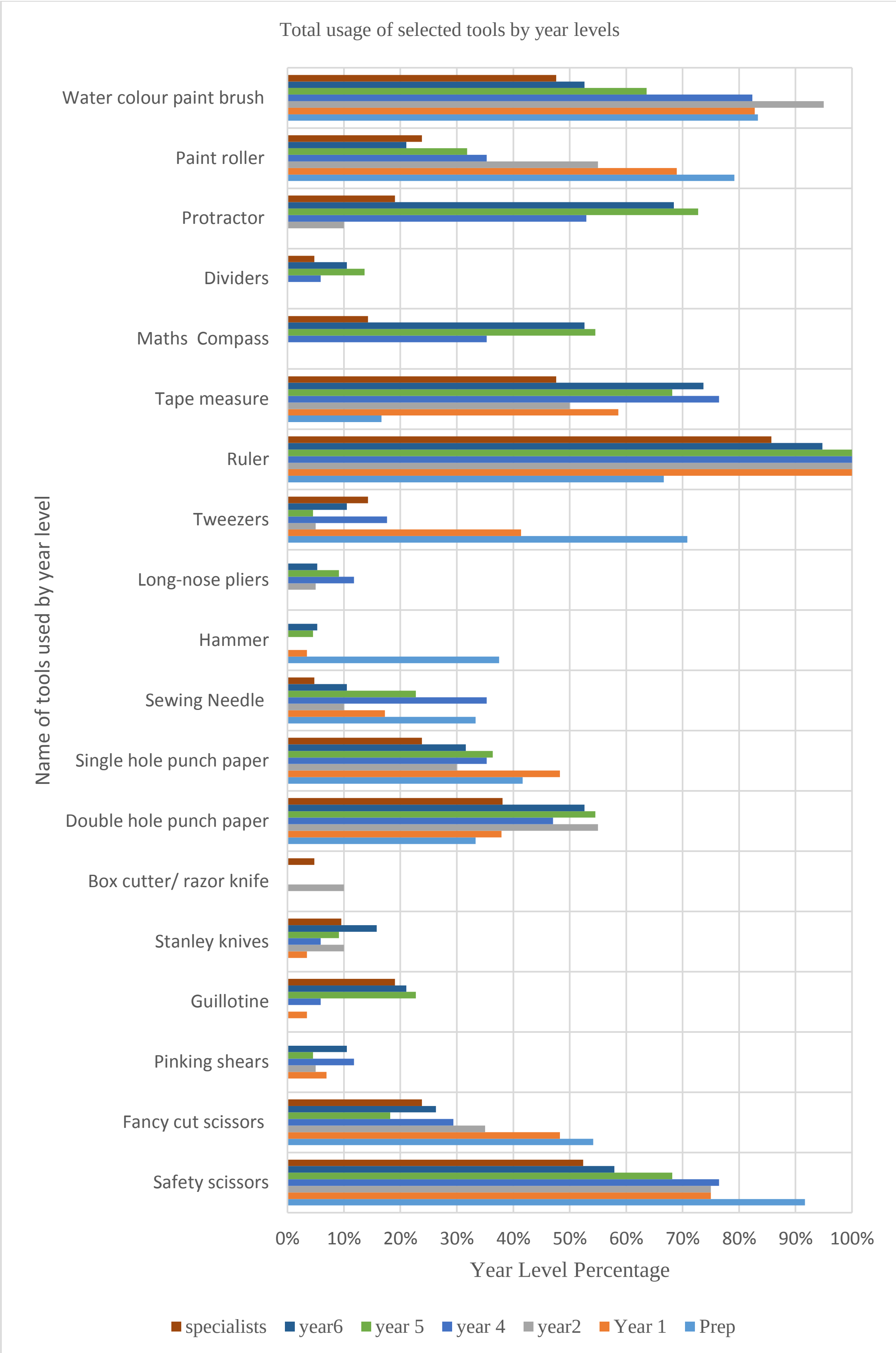

Figure 35. Tool use by year level.

Figure 36 represents all tools used in the curriculum bands areas of prep to year two. The most common tools indicated are scissors, hole punches, tweezers, rulers and painting instruments. Whilst there are slightly more opportunities given at the ad hoc level there is a close similarity to the instructional level. For example, 53% of teachers indicated that they provide ad hoc opportunities for children to use safety scissors and 45% of teachers indicate that they provide developmental instruction. This introduction to the use of new tools is what was expected across every year level in primary school and is replicated somewhat with the introduction of maths compass in upper primary year levels. Whilst 37% of teachers indicate allowing children to use a double hole punch in an ad hoc manner, whilst 32% provide developmental instructional opportunities, it would be interesting to investigate what developmental instruction was conducted with the double hole punch and the single hole punch. There were no opportunities in prep to year two for mathematical protractors nor compasses, though children had opportunities to engage in an ad hoc manner with tape measures 25% of teacher indications and 19% for developmental instruction. It would be interesting to link instruction in the use of tape measures in these early years with children's misconceptions in tape measure maths activities in upper primary years, especially in light of teachers' lack of training.

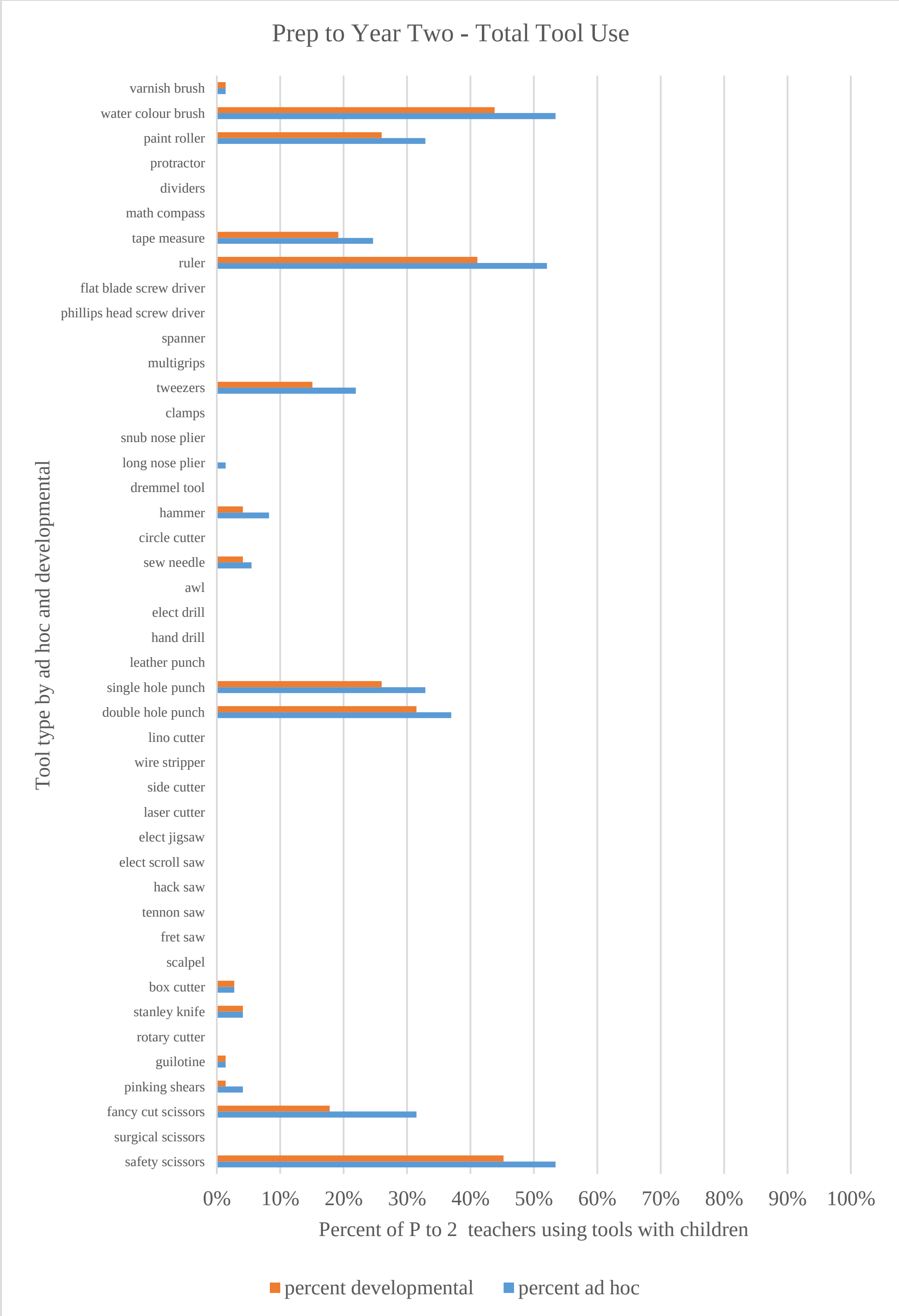

Figure 36. Prep to year two total tool use.

Figure 37 indicates those tools most commonly used by children as indicated by teachers in curriculum band year three and four. The tool range is similar to prep year two though tweezer use has decreased and a slight uptake in the use of sewing needles. Whilst the tools used is similar to the prep year two band, there is increased differentiation between ad hoc and developmental opportunities except in the area of mathematical tools.

Safety scissors have increased ad hoc use and developmental use has reduced from 45% to 13%. Similar results are shown with double and single hole punches. The introduction of mathematical tools such protractor, tape measure and compass have similar or higher levels of instructional developmental use than ad hoc opportunities. For example, protractor has 24% ad hoc use and 22% developmental use whilst maths compass has 11% ad hoc opportunities and 16% of teachers indicate the developmental instruction in the use. It was anticipated that these tools would further increase in years five and six. The inclusion of the tools with minimal or no use within the figures have been included to show the range of tools not introduced.

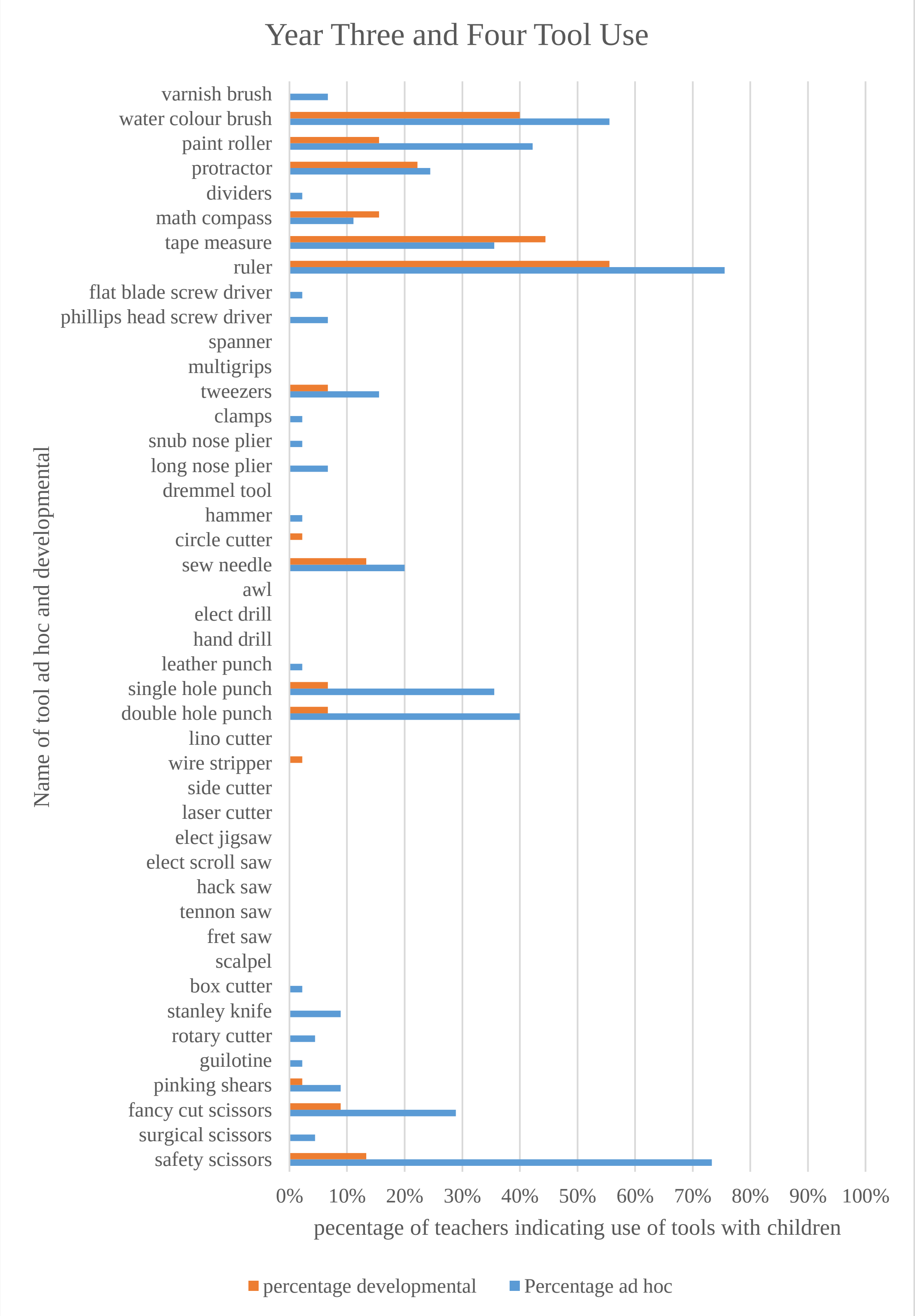

Figure 37. Tool use by year three and four.

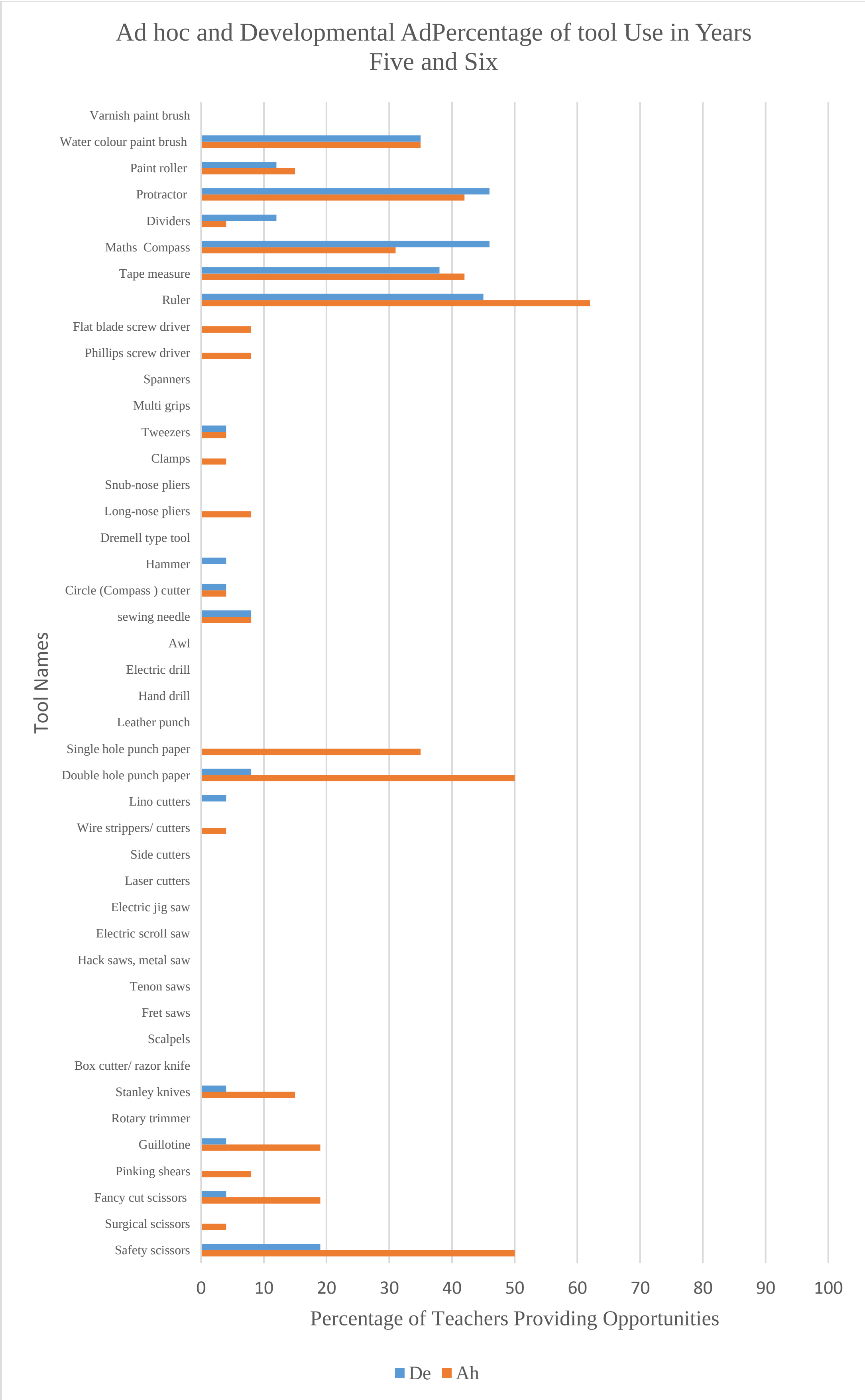

Figure 38. Tool use by year five and six.

Figure 38 indicates total tool use by band years five and six, the upper most band in primary school. Safety scissors were indicated being used in an ad hoc manner by 50% of teachers and developmentally by 19%. The expectation based upon year three and four was to see more ad hoc opportunities, greater than the 75% offered, and a greater decrease in the instructional level offered in safety scissors. The rise in developmental instruction in the use of safety scissors may be attributed to the need for more accurate cutting in technology and mathematics activity, or in the students needing instruction in the use of scissors to cut more complex concave and convex figures. There were similarities to band years three and four, notably highlighting the use of scissors, hole punches and mathematical tools especially at the ad hoc level.

Ad hoc comparisons for all teachers that indicated they are in the year five and six areas is shown in *Figure 39*.

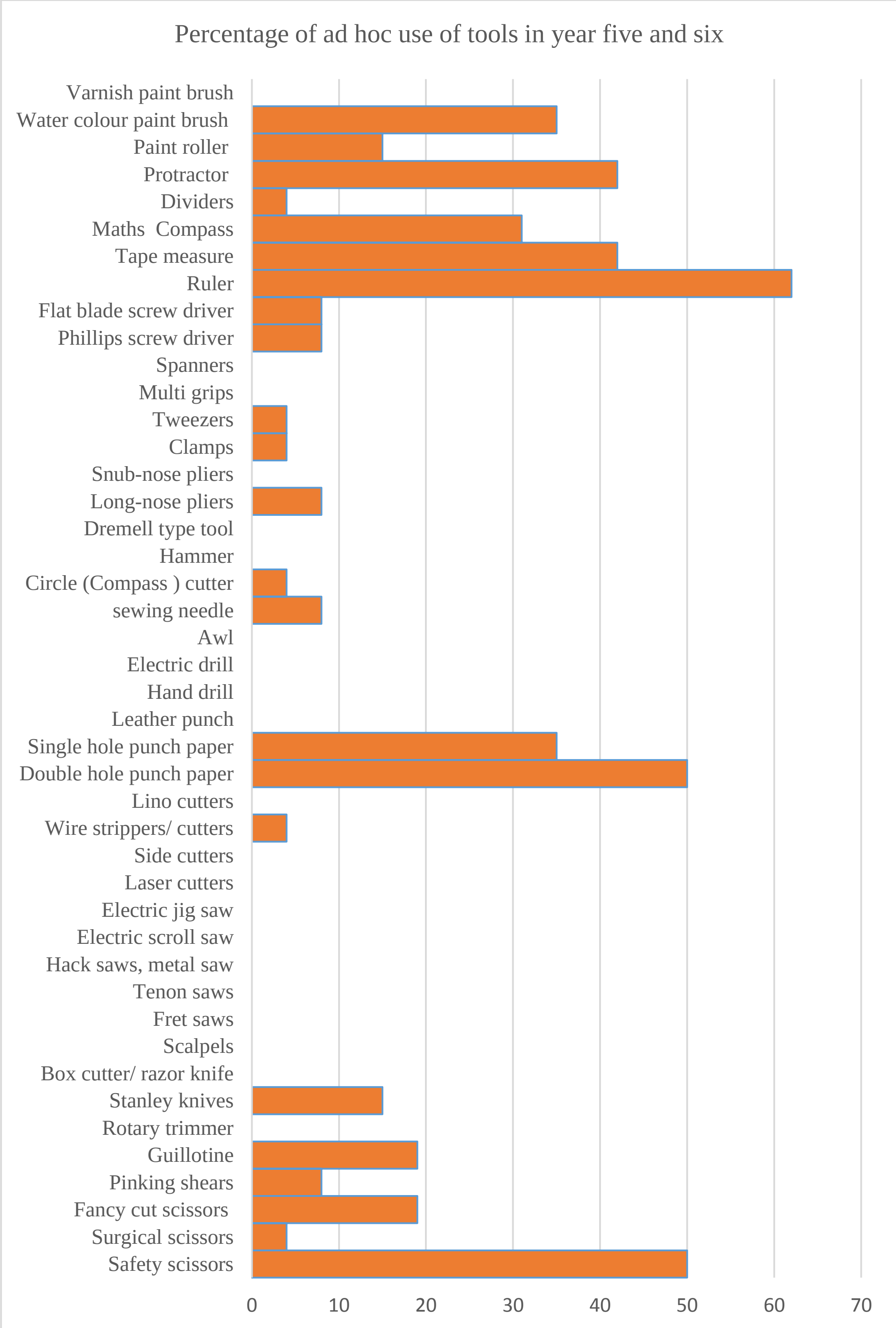

Figure 39. Ad hoc use of tools in year five and six.

Figure 40 shows a significant drop in the opportunities indicated by teachers in the ad hoc opportunities provided to students with maths instruments. Box cutters, pliers, saws, and hammers showed no opportunities.

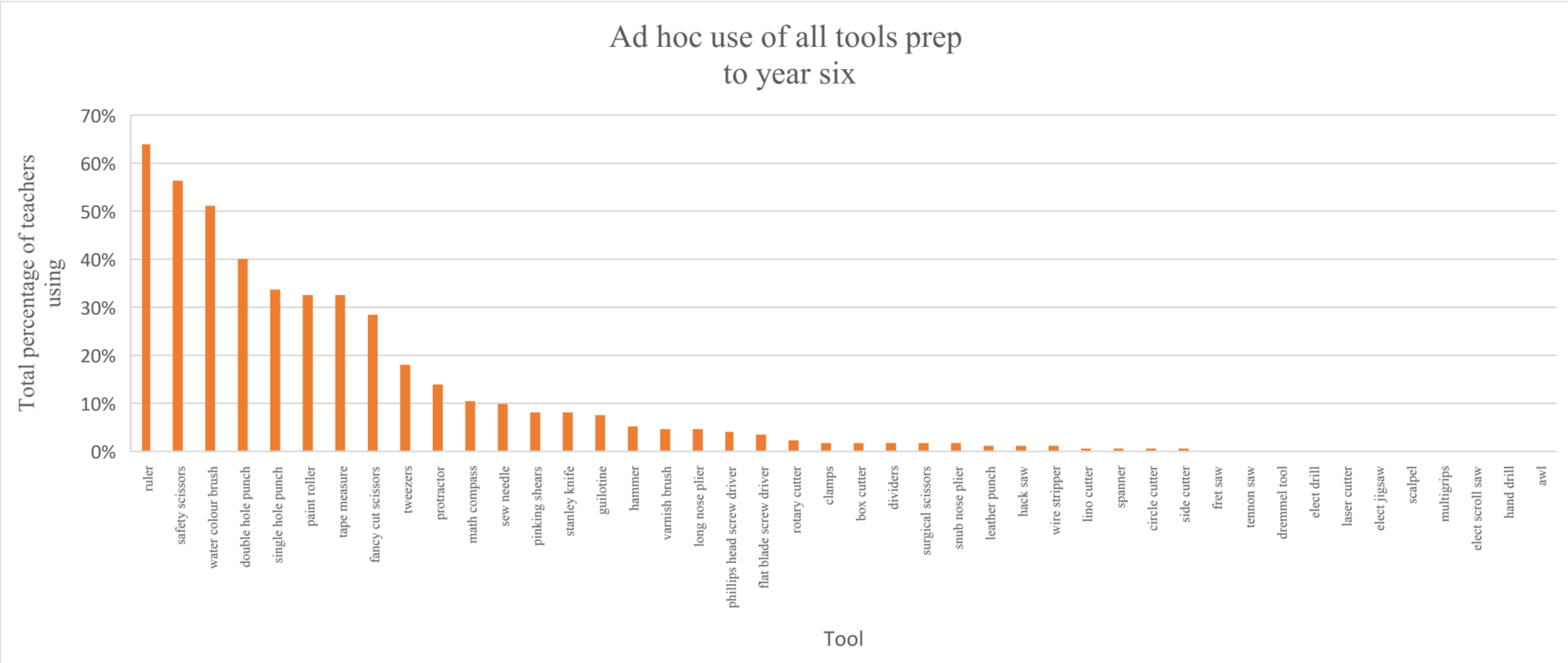

Figure 40. Ad hoc use of tools across prep to year six.

All tools by year level that teachers have indicated that they provide ad hoc opportunities for students to engage with is shown in *Figure 40* with ruler, safety scissors and double hole punch most commonly used by children in ad hoc way. About a third of teachers indicated that students have incidental opportunities for using single hole punch, paint roller, tape measure and fancy cut scissors. Less than one in ten teachers indicated that the students had opportunity to engage with mathematics compass, sewing needles, Stanley knives, varnish brushes, or pinking shears. Whilst safety may be a concern for not using tools such as Stanley knives and box cutters the same could not be said for varnish brushes. Here the problem may be access to the brushes or the lack of varnish paint to be used because wood is not used.

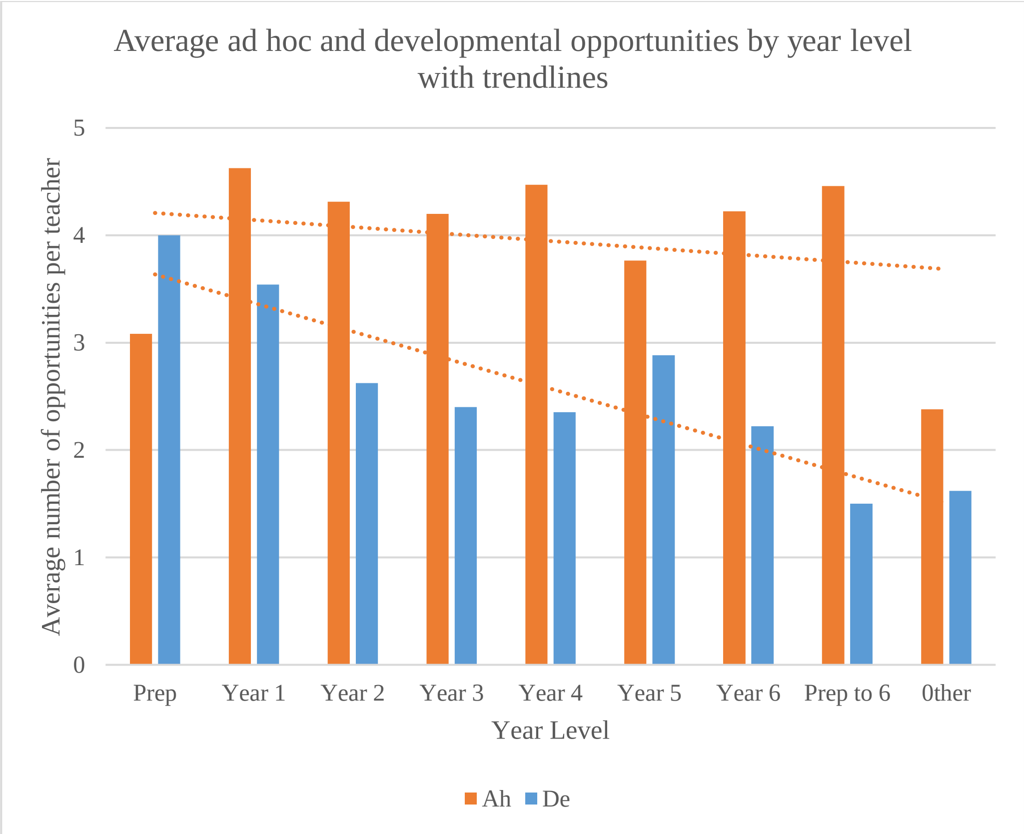

Figure 41. Average ad hoc and developmental opportunities by year level with trend lines.

Figure 41 shows the number of tools on average used by children in the classroom. There is a decreasing number of tools instructed in shown by a general trend downwards in the number of tools taught to children developmentally from four on average in prep year to one and a half in year six. This is shown by the orange trend line. Several reasons for this decline are articulated in the interviews as being linked to time required to actually complete a project using tools and safety because of the lack of experience with the tools.

The opportunities to practice also reduce with ad hoc opportunities also decreasing over the primary year levels. The few opportunities to use tools in an ad hoc manner would equate to one opportunity per school term. This is shown by the ad hoc trend line in blue.

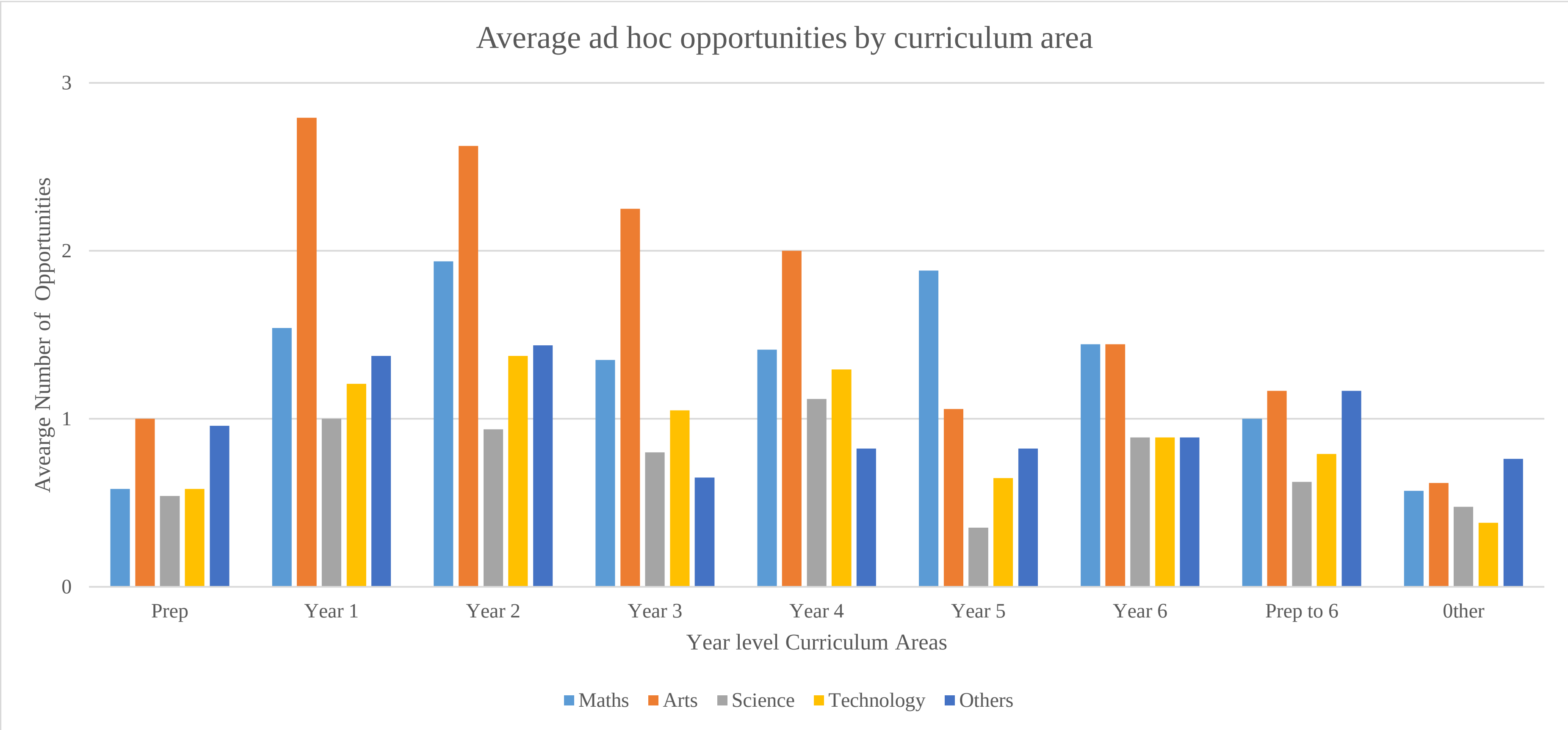

Figure 42. Average ad hoc opportunities by curriculum area.

Figure 42 shows an overview of where teachers indicated they most allowed ad hoc use of tools in each curriculum area from prep to year six. The average number of ad hoc opportunities of tools used in each curriculum area decline from nearly three in arts in year one to one in arts in year six. The arts had the most opportunities in each year level except year five where maths curriculum provided the most opportunities. Maths was the second most used in an ad hoc manner of the recognised curriculum discipline areas. Prep, year one, year two and year six indicated that they used tools in other areas more so than in mathematics. These other areas may include culturally significant activities conducted across the school but not as part of the normal class activities. Examples of this may be in making Mother's Day gifts or making indigenous artefacts such as boomerangs on indigenous celebration days. Private conversations with a mathematics professor at University of Southern Queensland indicated that one of the areas that students struggled with in high school extension mathematics classes was in the manipulation of tools and materials in the class. The lesser response to ad hoc use of tools in the prep year level could be aligned with more developmental opportunities.

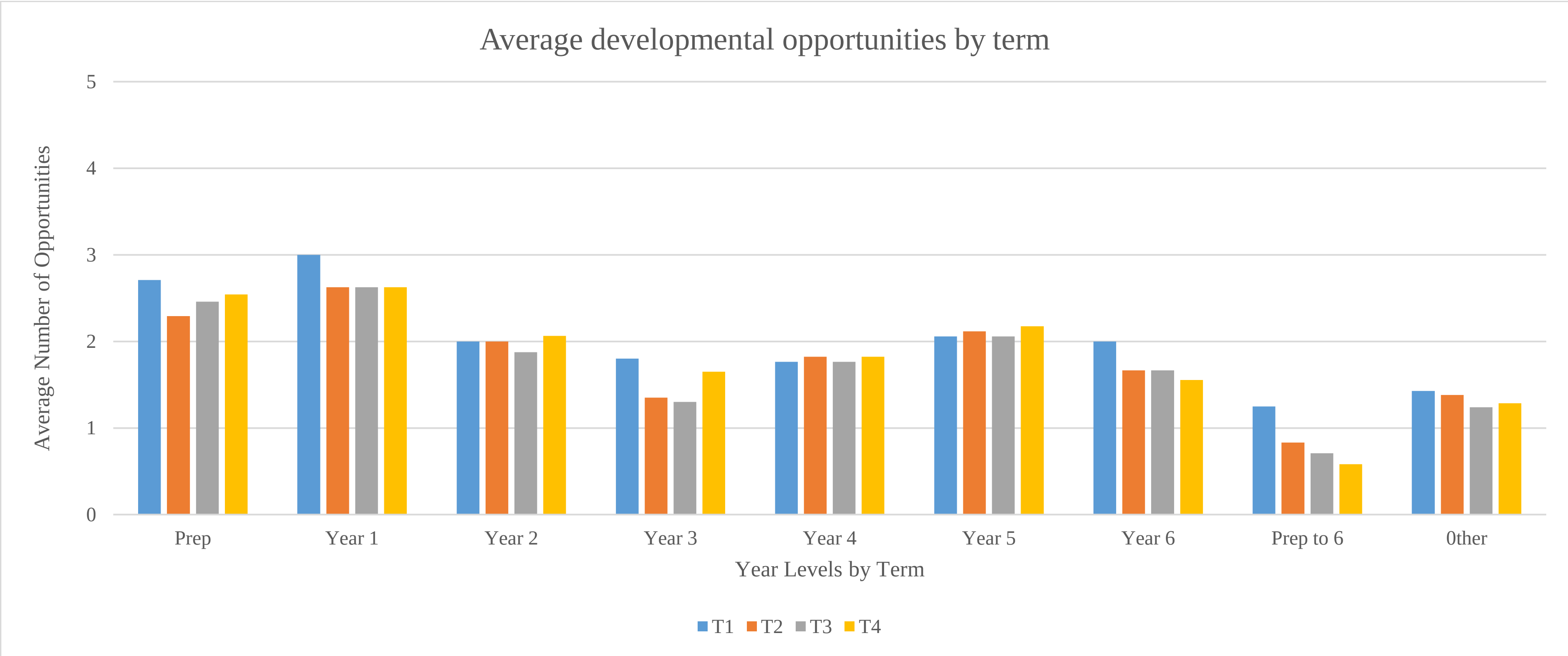

Figure 43. Average developmental opportunities by school term.

The average number of instructional type developmental lessons provided by teachers as indicated in *Figure 43* do not show a significant trend in each year level to do more instructional activities in term one and less in term four of the school year. In the foundation prep year there is slightly more in term one but then the trend in the other terms is to increase instruction from term two to four. In year six the trend is what would be expected in that more developmental opportunities occur in term one then less by term four, although the average number difference between all terms is small. Year three, term four sees a slight jump that may be aligned to Christmas or cultural activities, “but I suppose now we only use things (tools, materials and adhesives) now in the new curriculum for making something for Mother’s Day (Culturally significant days)” (Interview P5)

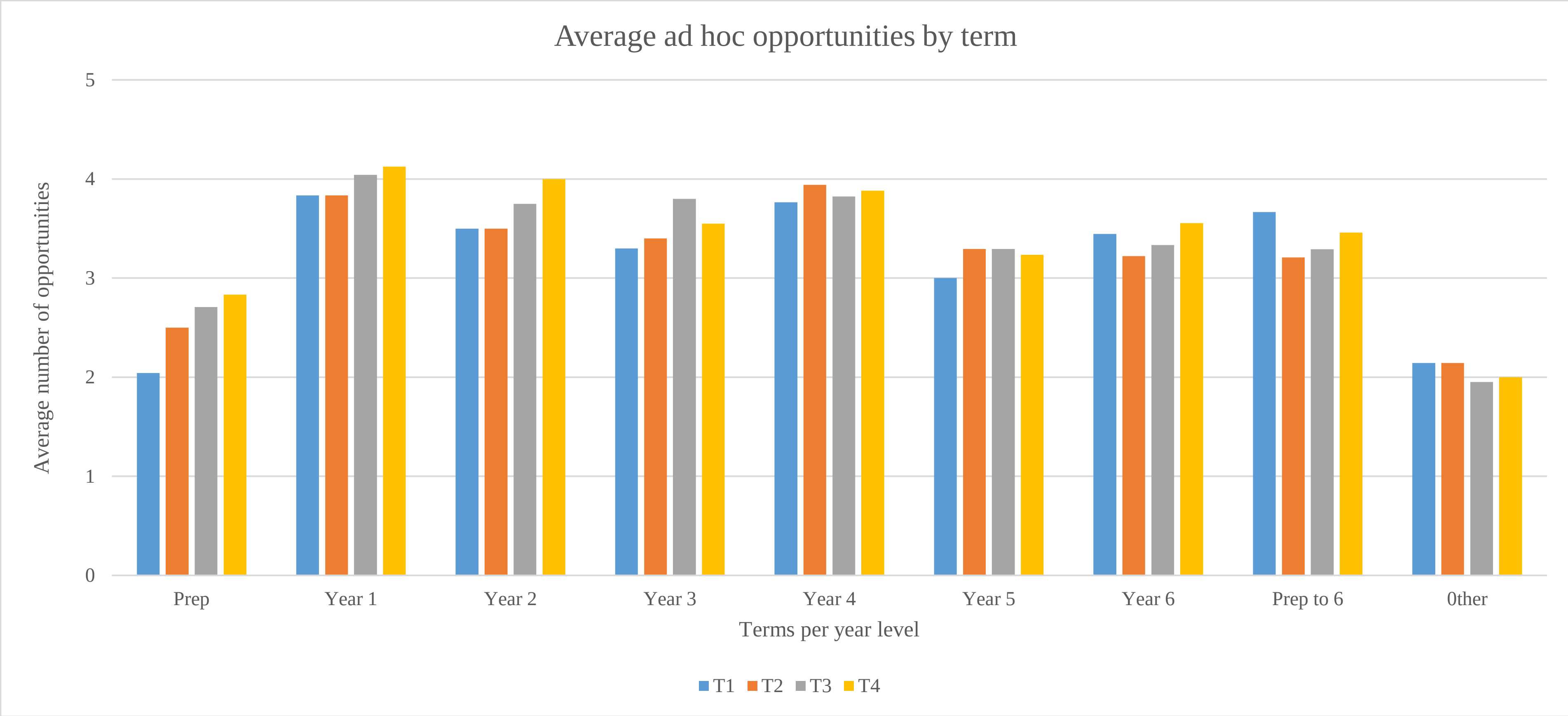

Figure 44. Average ad hoc opportunities across the school by term.

In the prep year there is a gradual increase in the ad hoc opportunities provided to the students as indicated by the survey as shown in *Figure 44*. However, the other year levels in *Figure 44* show a slight decrease overall in number of ad hoc opportunities across the primary school with similar numbers in each term for each year level with a little spike in term four of each year.

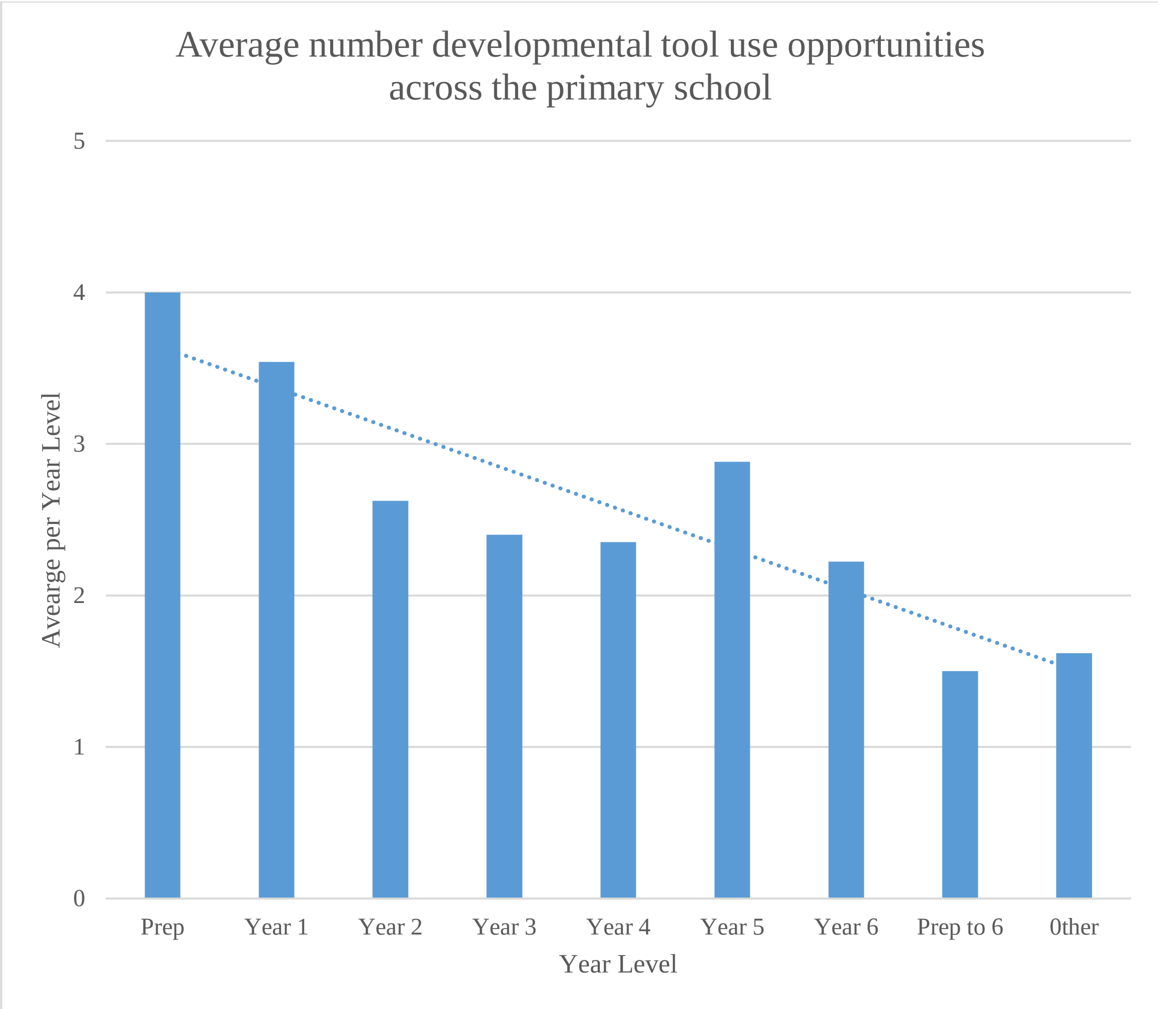

Figure 45. Average developmental opportunities with trend line.

Figure 45 shows the gradual decrease in the total number of instructional opportunities given to students in primary school. This decrease is surprising as it also takes into consideration the number of instructional activities given in years five and six with regards to the mathematical instruments highlighted in Figure 32. With the number and variety of tools indicated in the curriculum documents this is the reverse of what was anticipated where at the very least there would be similar or increasing numbers across all year levels as science and design technologies introduced new tools.

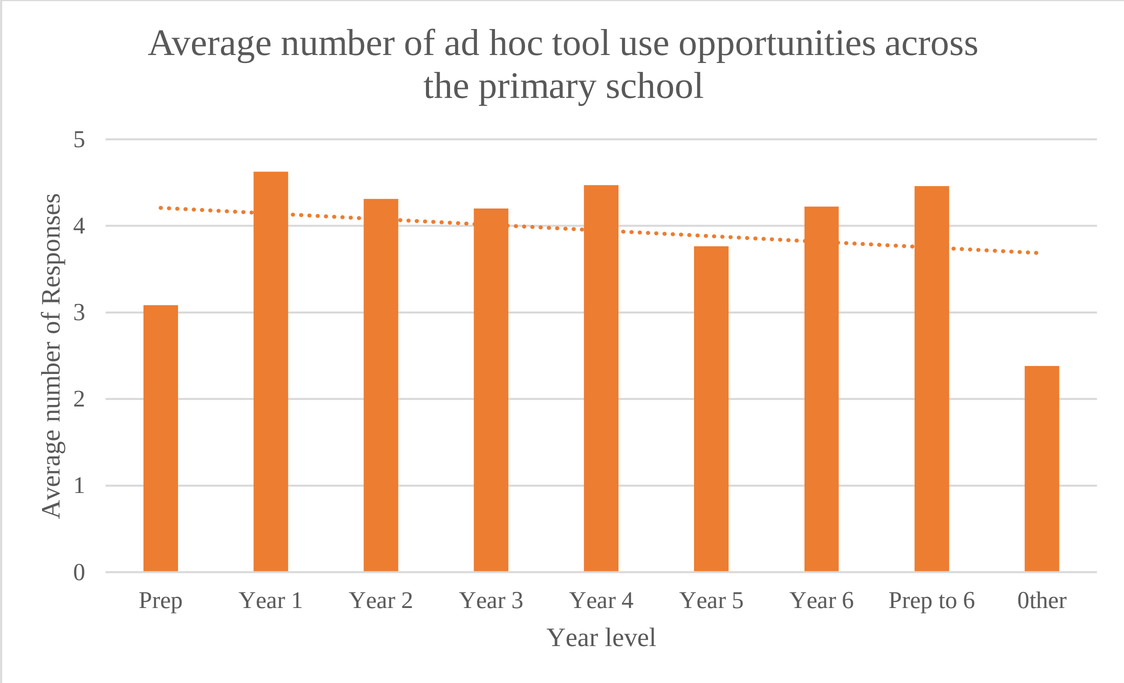

Figure 46. Average number of ad hoc opportunities across the primary school.

The average numbers of ad hoc opportunities to use indicated in *Figure 46* seems low, with an overall slight decline from year one to year six. This would indicate that not enough practice time is being allocated in the development of fine motor skills including strength, persistence and control. “There are a lot of kids that don’t have very good fine motor skills, they will write for a few minutes and then go my hand hurts because they don’t have the muscle strength in their hands” (Interview P61).

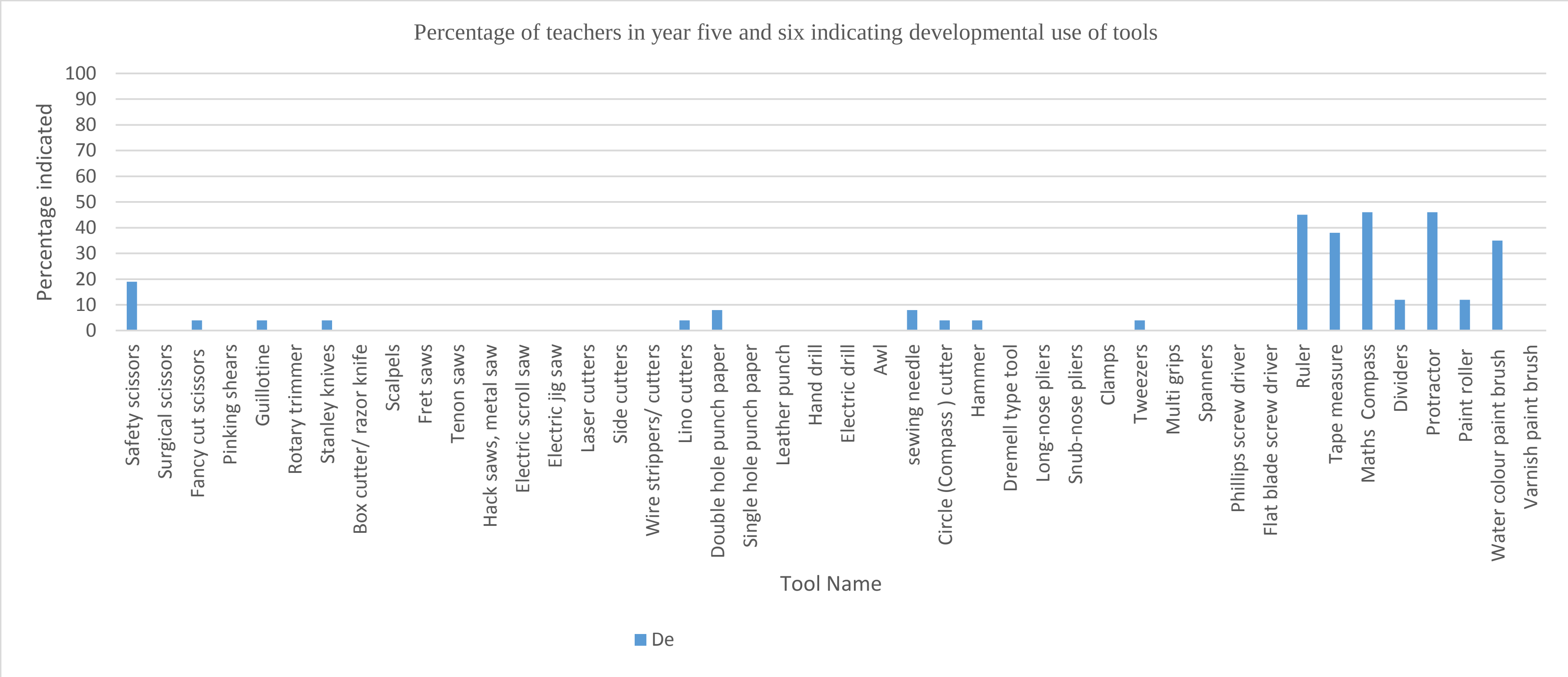

Figure 47. Percentage of teachers in year five and six indicating developmental use of tools.

With the advent of electrical circuits in science curriculum, design tasks and makerspace activities it would be anticipated that the introduction of wire cutter, pliers and possibly screw drivers would see an increasing percentage of teachers in upper primary years beginning to appear. However, from *Figure 47* this is not the case, a teacher indicated that that when making a prototype in design technologies the students only make a drawing and don't actually make the prototype (Interview p. 90).

5.13 Chapter summary

The effective and efficient use of tools can impact on the learning opportunities that children have in learning throughout their lives. Many of the tools that children use traditionally from the earliest year levels provide opportunities to strengthen the child's developing muscles and their fine motor control. The development of skills requires regular manipulation of the muscle groups that are common to a variety of tools, for example pencils, scissors, side cutters and squeeze bottles. They learn to coordinate hand eye finger movements of one hand then in tandem. "All children find using a ruler and pencil together quite tricky, so you cannot just assume they can do it because when they come to do it, to do an accurate math or scientific drawing the lack of skill inhibits you actually doing that activity" (Interview P 27). The ability to use a variety of tools as an extension to the hand and arm allows for the consideration of transversal skills to be useful life skills. "Some countries and economies use specific terms and definitions of transversal competencies in their policy documents (e.g. "21st century skills" in Malaysia, "life skills" in Thailand, "generic skills" and "values and attitudes" in Hong Kong SAR [China], and "zest for living" in Japan). In India, the Central Board of Secondary Education (CBSE), one of India's largest boards, uses phrases such as "life skills," "co-curricular skills," "attitudes" and "values" to represent transversal competencies. (UNESCO, 2016b, p. 7). A similar list is stated by Lucas and Smith (2018, p. 1) "they are also referred to as '21st-century skills', 'dispositions', 'habits of mind', 'attributes', 'competencies', 'non-cognitive skills', 'soft skills' or 'traits'". The effective use of these physical life skills assists in the development of products and hence the extending of creative and innovative capabilities in the development and use of materials, tools and adhesives. Conversely the lack of instruction in and use of using tools has a flow on effect in then not using a wide range of materials and adhesive methods. The following chapter, chapter six, further elaborates on the study data with a focus on materials used within the primary school.

6 Materials used in the Primary School

6.1 Introduction

This chapter, chapter 6, focuses on materials used in the primary school. Paper has the largest range and is divided into two section, photocopy papers and other papers including butcher's paper. The other sections within this chapter are plastics, fabrics, wood metal and electrical circuit components such as wire. An overview of all the materials indicated within the survey are shown in .

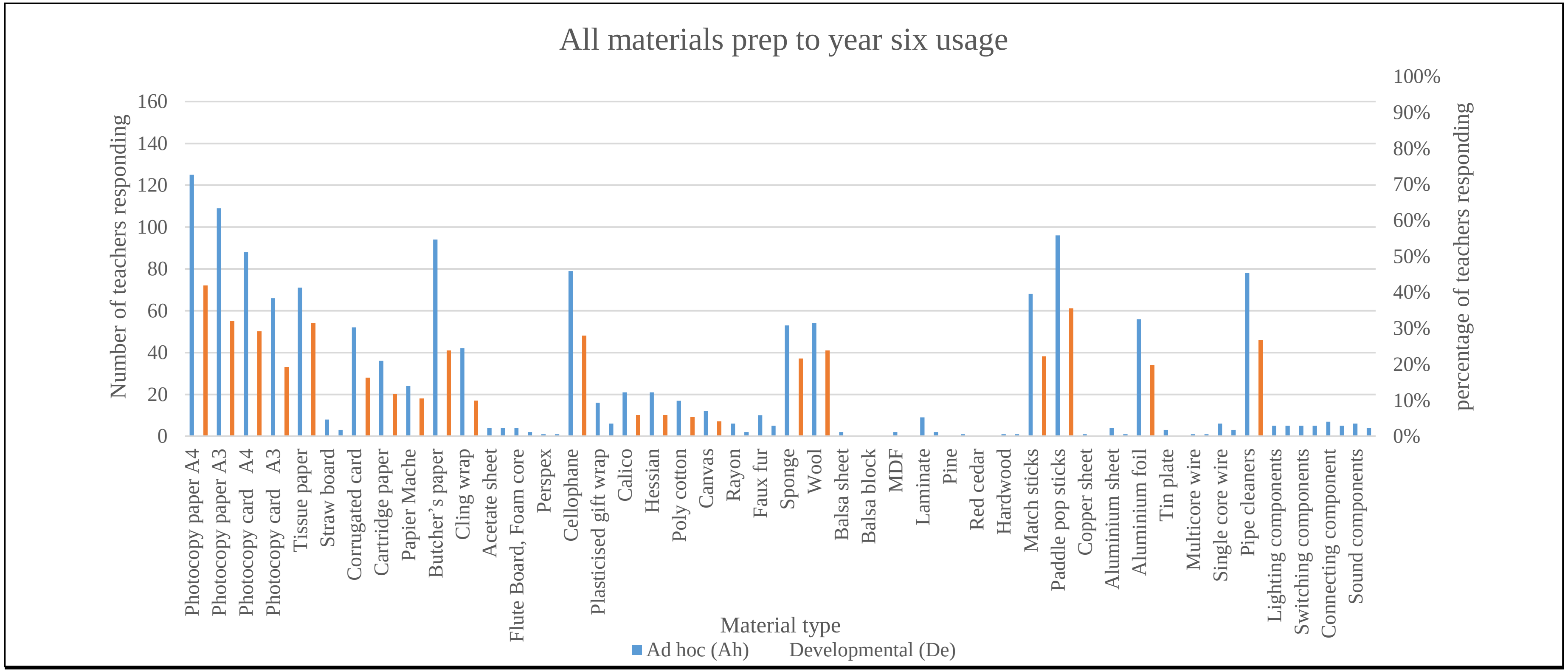

Figure 48. Prep to year six usage of materials.

6.2 Paper usage in primary school

Photocopy paper is any paper that can be used within the school copier. The paper usually comes to the school in cartons of five reams, with each ream having 500 sheets. The size of the paper for photocopiers in schools is usually A4 or A3 size. Other papers and card come in A3 or A4 but also in larger and smaller sizes as well.

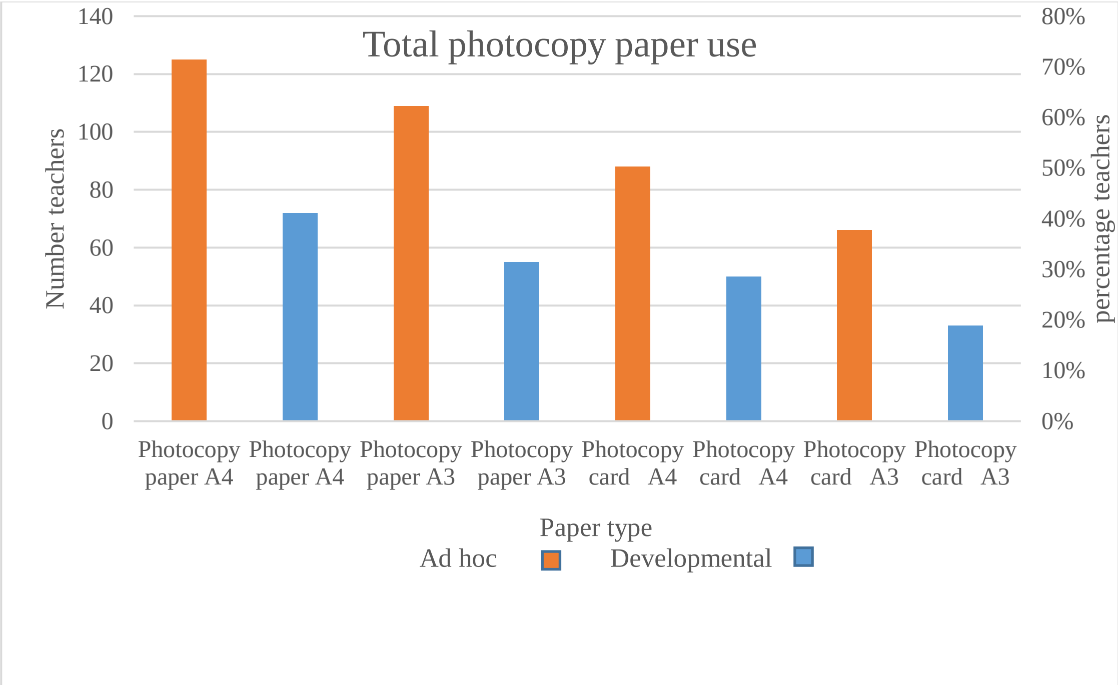

Figure 49. Photocopy Paper use across the primary school.

Figure 49 shows the use of photocopy papers used across the school, with ad hoc use shaded in blue and developmental usage in orange. The greatest number of teachers (seventy percent) indicating that they are using A4 copy paper with the children, which then decreases across A3 paper, A4 Card, and A3 card. This is followed by a similar pattern in the developmental use of photocopy papers. Photocopy card is usually more expensive than paper.

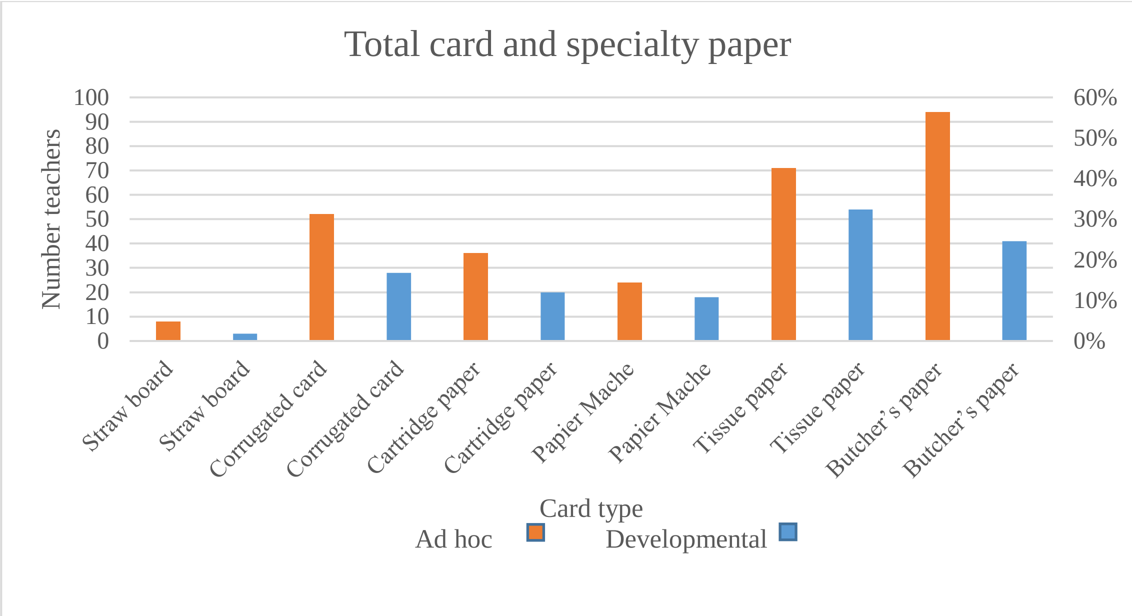

Figure 50. Other card and paper.

After the photo copy papers the drop in other paper and card as shown in Figure 50 is significant with the number of teachers using stiffer card such as straw board or corrugated card less. The left scale of Figure 50 indicates the number of teachers whilst the right scale indicates the percentage of total teachers. Straw board is thick card usually greater than 300 gsm, like cereal boxes. Only butcher's paper is used by more than fifty percent of teachers. Some teachers indicated during the data collection phase of this study, that they didn't know what some card was including cartridge paper and straw board.

6.3 Plastic usage in primary schools

Plastic maybe identified in schools by the different types for example food wraps are thin sheets on a roll whilst acetate sheet is stiffer. Foam core and flute board are more rigid and thicker and used in model making and signage. Plasticised gift wrap often has a thin metal coating to make it shiny. Cellophane is also used as a gift wrap.

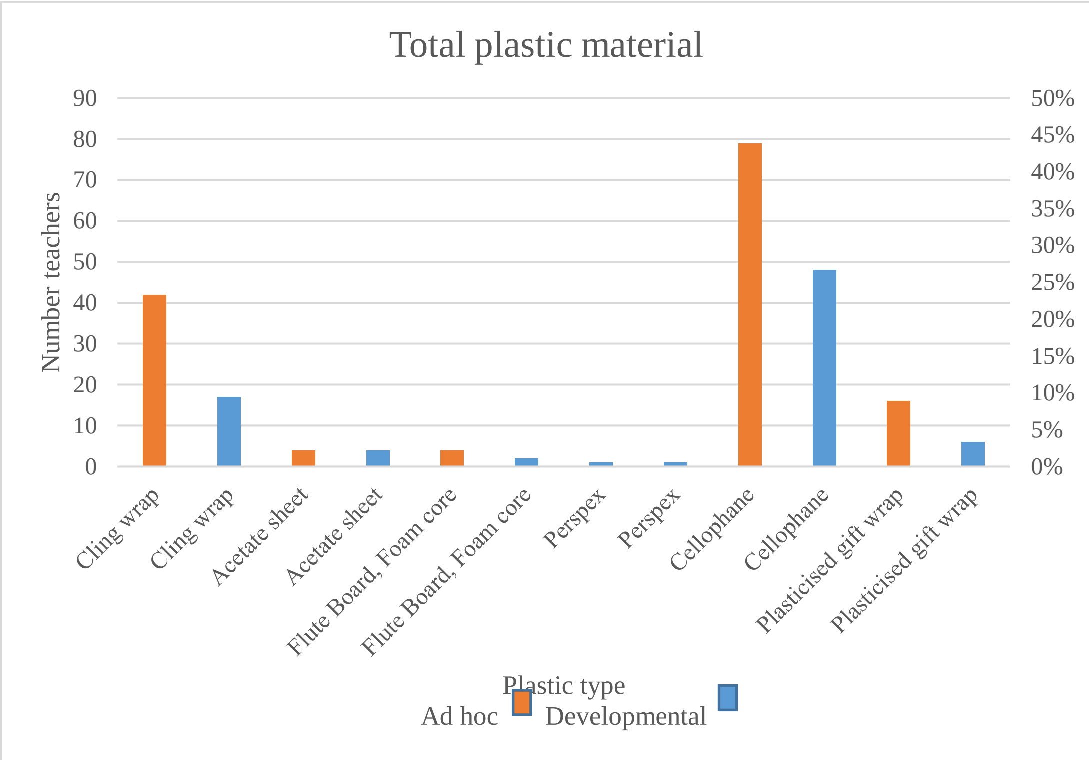

Figure 51. Plastics used across primary school.

Plastics as indicated by Figure 51 are used by less than fifty percent of teachers, with cellophane the most common to be used. After cellophane cling wrap was the only plastic material used by more than twenty percent of teachers and that in an ad hoc way. Flute board, Perspex, and acetate sheet were used by less five teachers across the total population surveyed.

6.4 Fabric usage in primary school

The potential range of fabrics available to primary schools is large. Calico and hessian offer broad measures cheaply. Canvas is more expensive. Poly cotton and rayon are readily available and easy to manipulate. Faux fur can add interest to model making.

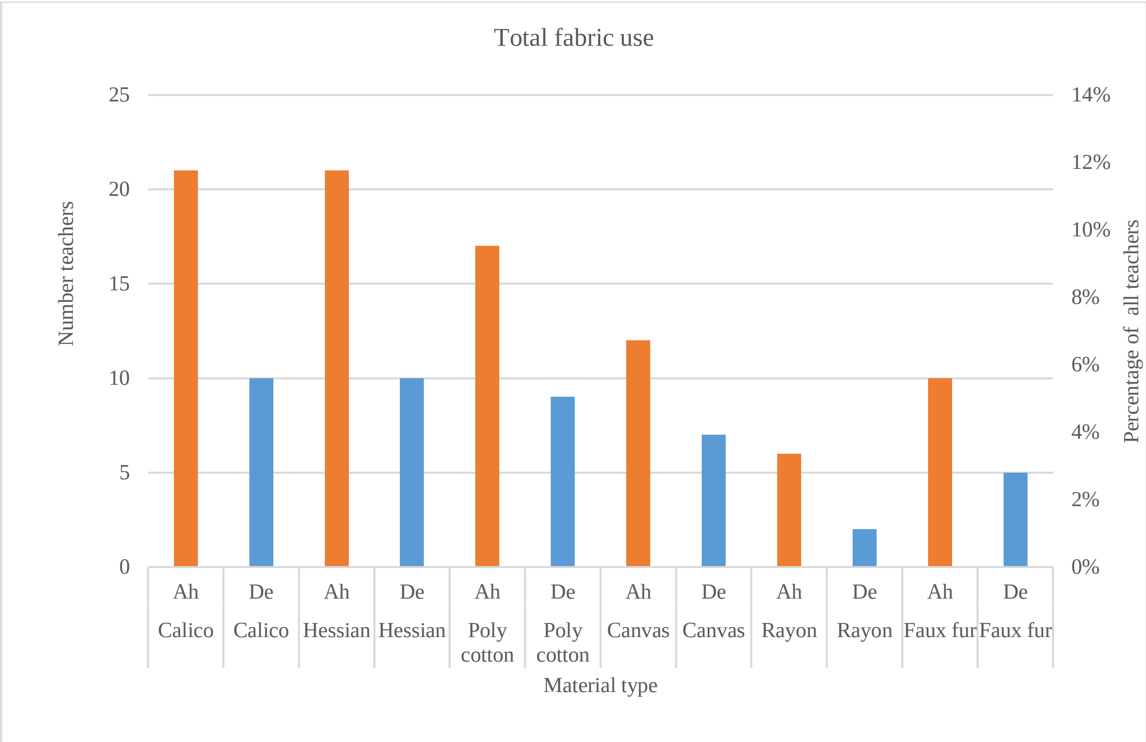

Figure 52. Fabric material used across the primary school.

Fabrics indicated in *Figure 52* show less that fifteen percent of teachers use these materials in an ad hoc way ad less than ten percent developmentally with children in their class. Ad hoc use of calico and hessian are used by twenty-one teachers each across the primary school years. Materials such as faux fur and poly cotton were often associated with constructing puppets in English study but now "you don't do puppetry with English" (Interview P97). Puppetry in the Australian Curriculum for primary years now only occurs in drama (ACADRM028) where students manipulate puppets to tell stories but do not necessarily make them, and languages other than English such as French, Chinese, Japanese, Indonesian and Hindi.

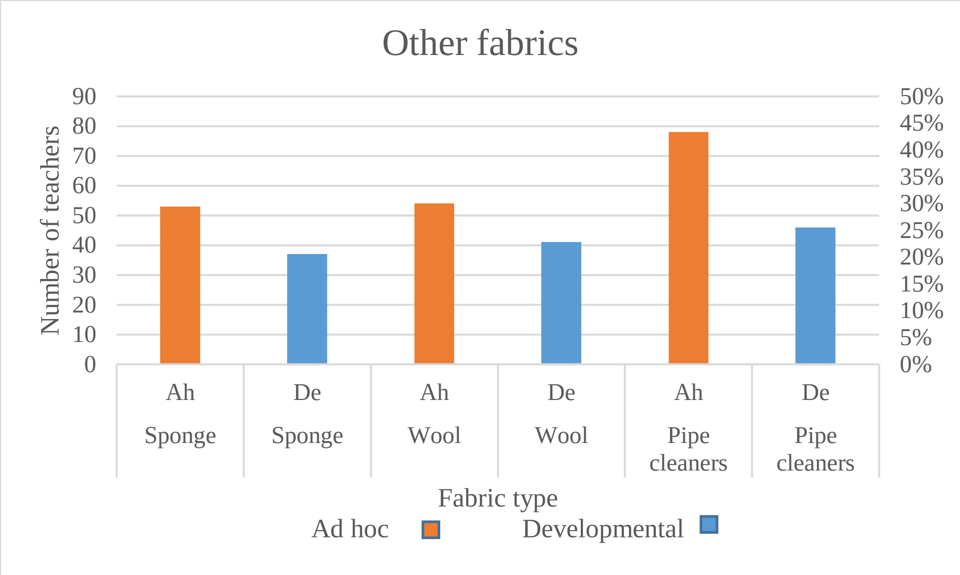

Figure 53. Other fabrics.

Figure 53 indicates that wool is used by teachers with fifty-four teachers indicating they use it with children. This was a confusing item because the survey did not delineate between balls of wool and wool as a sheet of material. Similarly sponge caused some concern as raised by the interviewees in trying to identify specifically what types. Just over thirty percent of teachers indicated that they used wool in and ad hoc manner.

6.5 Wood use in primary school

The use of wood in the primary classroom adds potential beyond the use of cardboard. Cheap wood available to primary schools include pine and MDF. Match sticks and popsicle sticks are also readily available.

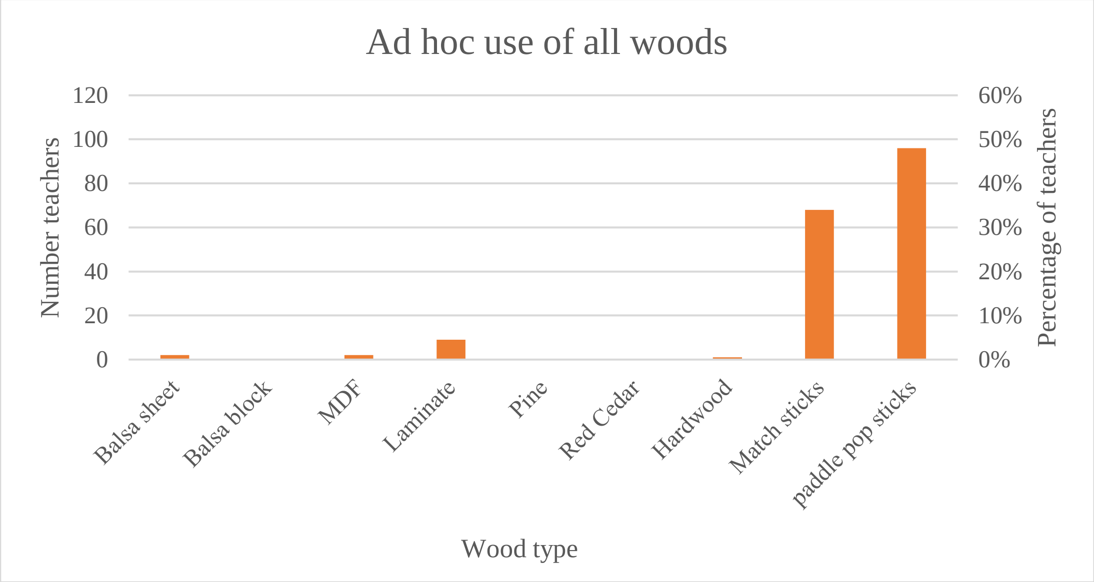

Figure 54. Ad hoc use of wood across the primary school.

Paddle pop sticks and matchsticks lead the way in the ad hoc use of wood *Figure 54* though this survey did not delineate whether these sticks were used as part of construction, modelling or as counters and three-dimensional skeletons in maths activities. These mathematics activities were seen in classrooms when visiting for the interviews related to the research. Other wood such as balsa, pine and MDF were generally not used. Laminate in the wood section referred to plywood and similar laminate though on leaving the surveys one teacher quipped that they used the plastic laminator to make and laminate posters for her classroom.

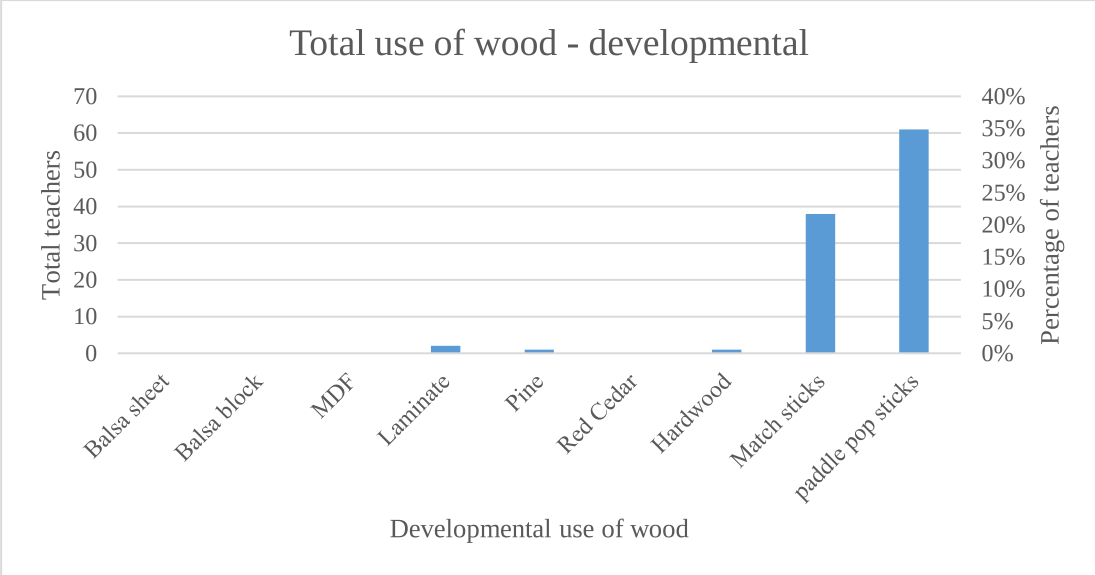

Figure 55. Developmental use of wood in primary school.

Figure 55 also showed that more commonly available wood in southern Queensland were not used except for paddle-pop sticks and matchsticks. Clarification on the use of match sticks and paddle pop sticks usage could be part of a follow-up study. This lack of sheet wood would indicate that there should be a lack of use of tools used to shape and size wood sheet such as saws, hammers and nails. This is what is exactly reflected in the list of saws in this study are those that this researcher has used in primary schools throughout his career. The saws are often associated with carpentry as is the hammer.

Table 12

Total Saw Use.

Saws	Ad hoc		Developmental	
	number	percentage	number	Percentage
Fret Saws	0	0%	0	0%
Tenon Saws	0	0%	0	0%
Hack saws,	2	1%	0	0%
Hammer	9	5%	9	5%

Table 12 shows there are no saws being used. In the interviews a middle year primary school teacher indicated why they didn't use wood because "we don't order it the only wood they use really is paddle pop sticks that's the only thing we use we don't use anything else." (Interview p68).

6.6 Metal use in primary school

Metal access in the primary school is recycled metal containers and sheet metal such as aluminium foil. Other sheet metals such as copper are often used in science and art in schools.

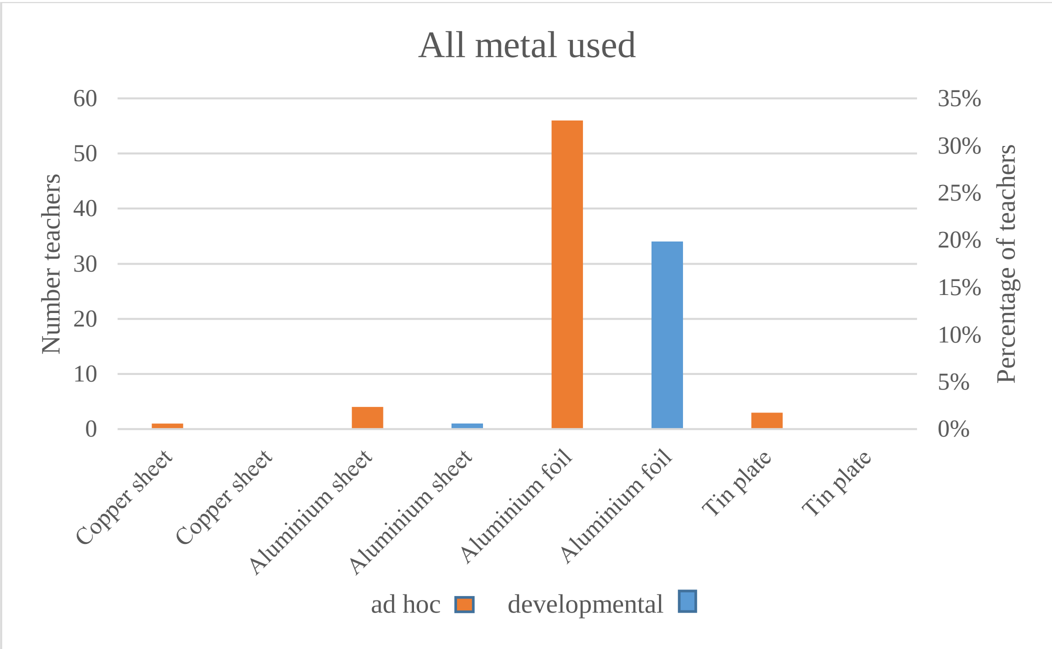

Figure 56. Sheet metal use in the primary school.

The use of metals is limited in primary school as shown in *Figure 56Figure 56.* Sheet metal use in the primary school.. Thin tinplate, copper and aluminium sheet are often used as part of science activities in electricity and in art for etching and sculpture, and is not usually found in the home, where as aluminium foil is found in the home for cooking. Aluminium sheet is often found cheaply in aluminium soft drink containers and used in sculptural activities, and science and design tasks on insulating and conductivity. The lack of tools associated with manipulating metal such as pliers and saws could be a reason for the lack of use of stiffer metals unlike foil which could be cut with safety scissors.

6.7 Electrical Circuit Components

The section includes wire used in art and technology. Multicore wire is flexible and bends easily without breaking. Single core wire has a single strand and is more rigid.

Wires maybe insulated or not. Lighting components include incandescent bulbs or light emitting diodes (LEDS).

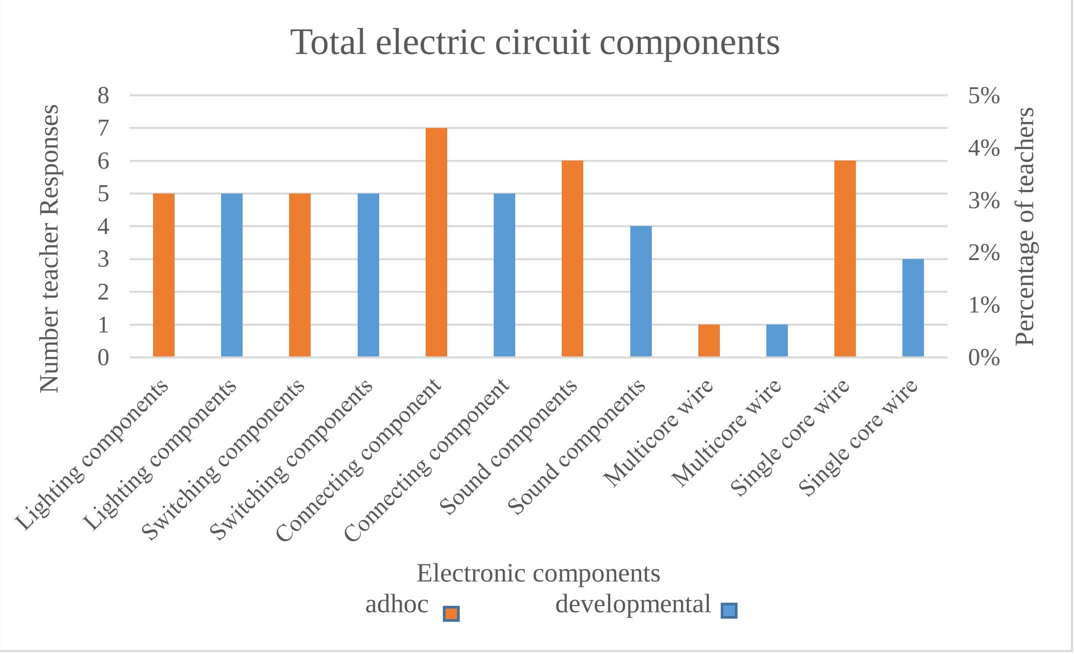

Figure 57. Electronic components used in simple circuits.

Electronic component as shown in *Figure 57* show very few teachers use simple circuitry or electronic components in their classrooms either with simple circuits or coding and robotics. The Lighting components such as light bulbs and holders, Light Emitting Diode (LED) lights, switching components such as toggle switches, paper clips and thumb tacks, roller switches, headphones and speakers and connecting wire were not used in great numbers by teachers as indicated in *Figure 57*. The same teachers that indicated that they gave instruction in the use of these items were also the teachers that indicated that they gave ad hoc opportunities for the use of the materials. Interestingly single core wire such as copper phone wire was more often used than flexible multicore wire as found in head phones and mobile flexible cords.

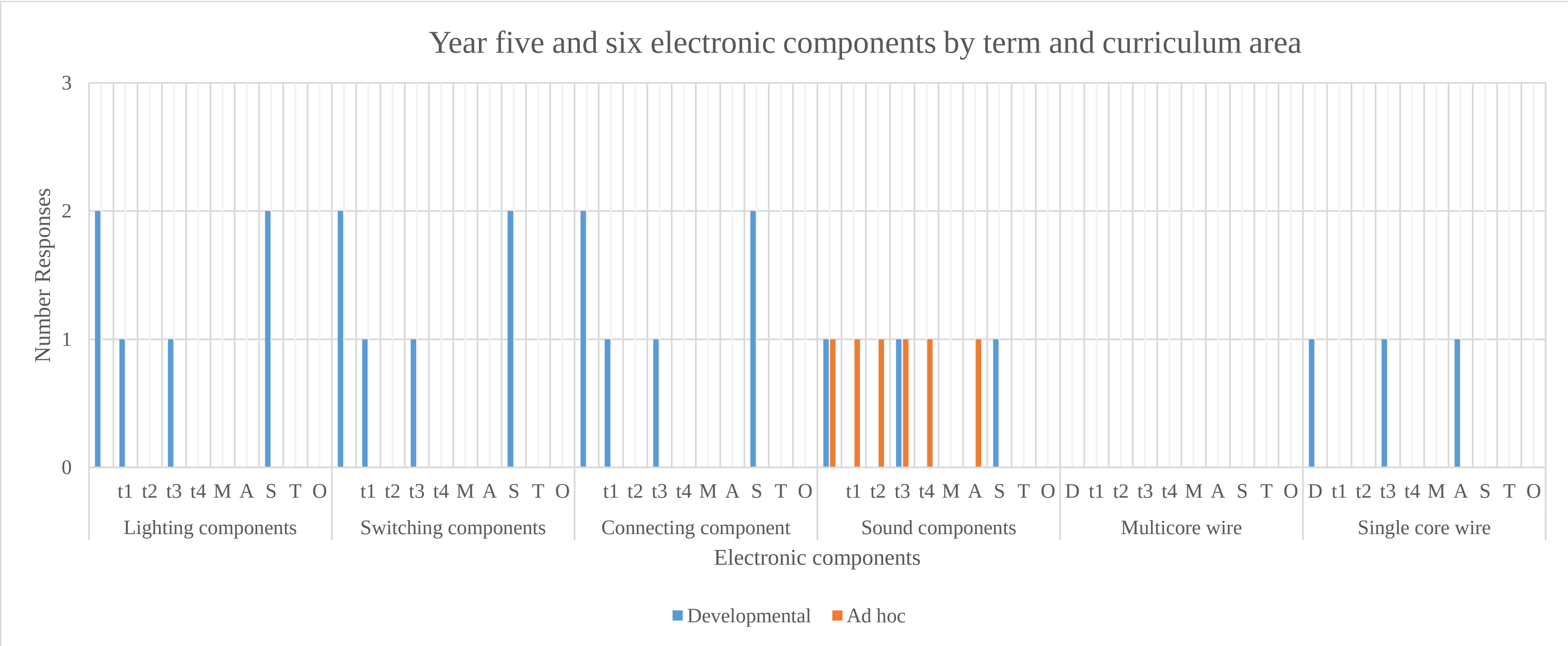

Figure 58. Year five and six teachers using electronic components.

Figure 58 shows only two responses indicating that teachers in year five and six are using electronic components, Year six is the year where the Australian Curriculum specifically mentions electrical circuits “Electrical energy can be transferred and transformed in electrical circuits and can be generated from a range of sources” (ACSSU097). Within the elaborations are references to switches, conductive materials and light globes. These are increasingly discussed in light of design technologies with particular reference to makerspaces, however only two teachers in year five and six indicate that they are using the components in either a developmental or ad hoc manner, and they are using these as part of science and not technology as indicated in *Figure 58*.

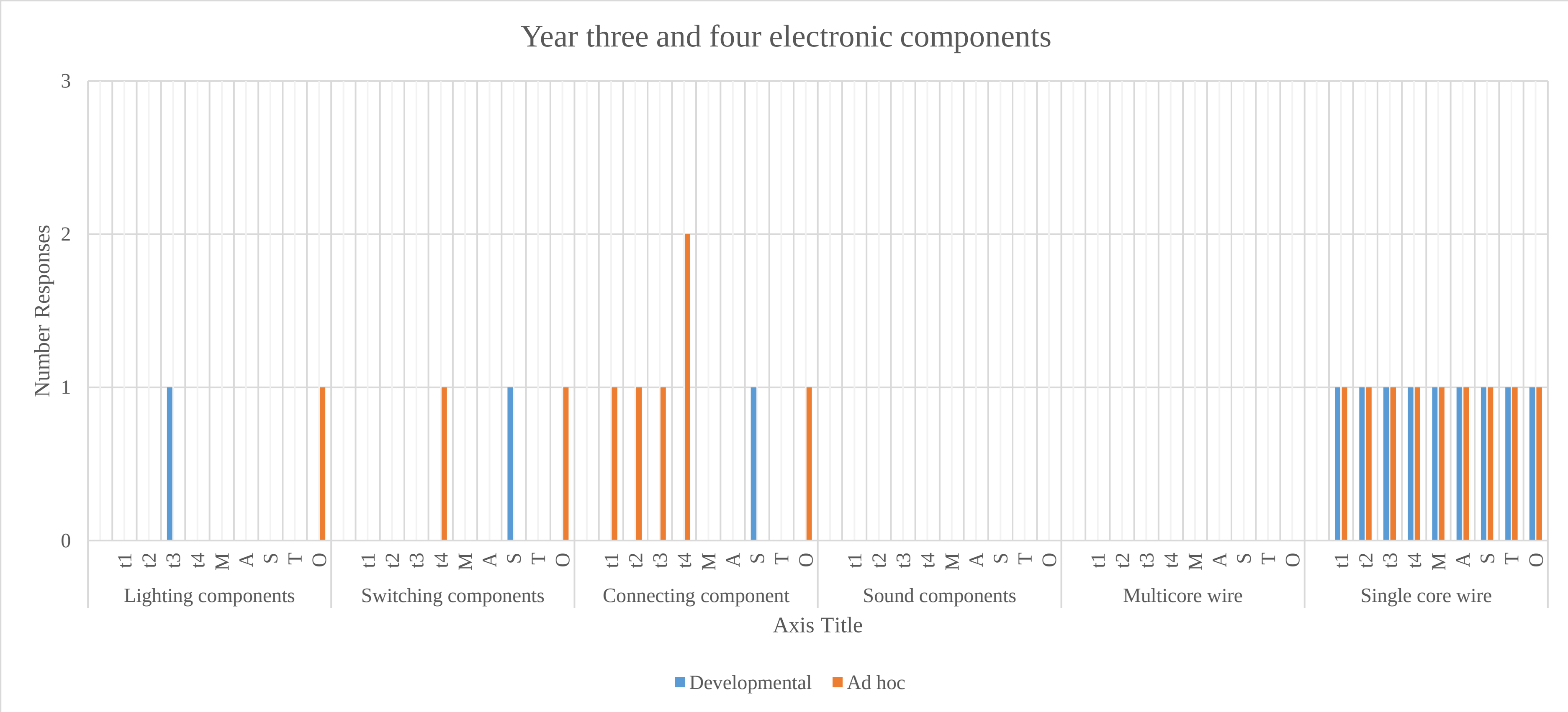

Figure 59. Year three and four teachers using electronic components.

Figure 59 shows that one teacher in year three and four indicated that they were using lighting and switching components in term four of the year in a curriculum area other than maths, arts, science or technology. Two opportunities were available in term four of the school year to be able to practice using electronic components.

6.8 Chapter summary

Chapter six highlighted the materials used by the participants in the study with children in the primary classroom. The data showed that photocopy paper was the most used of all the materials. Wood, metal and electrical circuit materials were not used across the primary classrooms. Fabric use was limited.

Chapter seven, the next chapter will focus on adhesive methods used in the primary classroom.

7 Adhesive methods used in the primary school

7.1 Introduction

Adhesive methods are employed to be able to join materials together, whether they be similar materials such as joining paper to paper or joining different materials such as wire to wood. Often adhesives as a noun are used in general parlance to mean glues or paste. However, in this study, adhesive methods will be taken in mean in a broader sense, the mechanism by which two or more materials are joined together and include, but not limited to, glues, ties and fasteners such as nails and screws. In the text of this research paper ‘adhesive’ and ‘adhesive methods’ are often used synonymously.

The broad range of adhesive methods means that for this study they need to be grouped. The data from the groups of adhesive methods were then tabulated then graphed. The group headings were glue, metal and wood working, sewing, stationery and ties. Some adhesives were applied by tools associated with them such as hot glue and rivets. Not all adhesive methods are suitable for all materials, though some materials work well with differing adhesive methods, for example soldering LEDs to conductive thread, sewn into clothing then soldering to electronic controllers that are glued to the garment in wearable technology. The groups of adhesive methods were designed to assist in analysing the data in this study and may further refined in future studies.

7.2 Glues used in the primary school

Glues used in the primary classroom include pastes such as Clag, glue sticks and gum that are effective with gluing paper. Acetate, PVA and hot glue are effective in gluing a broader range of materials such as corrugated card, fabric and wood.

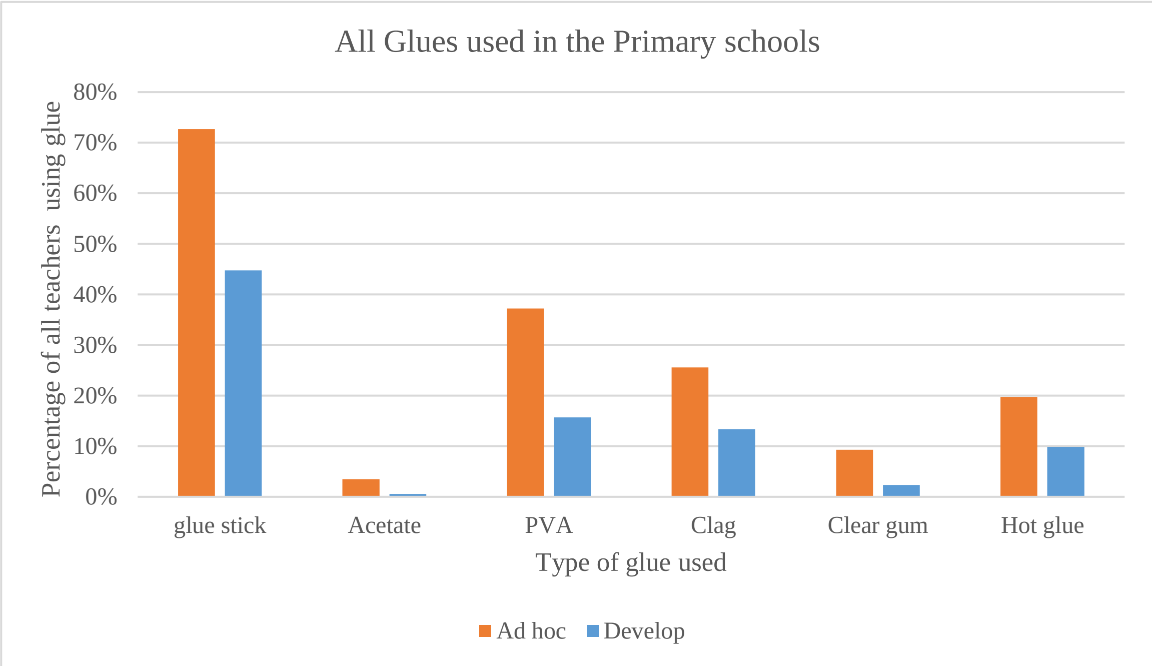

Figure 60. Glues used in the primary school.

The glue stick was the most popular adhesive method used in the primary classroom with 73 percent of teachers indicating that they use it in an ad hoc manner and 45% percent of all teachers indicating that they provide instruction in its use, as shown in Figure 60. Glue stick is a useful adhesive for paper and thin card without mess but is not strong enough for many art or technology projects. PVA or wood glue or white glue is often a better choice for these activities and 37% of teachers indicating they use PVA glue in an ad hoc manner. The disadvantage and advantage of PVA glue is that it takes a while to set, this drying time allows manoeuvring pieces together prior to it adhering but it requires patience of the user and or the use of clamps, yet only 16% of teachers indicate they provide instruction. Clag is a cheap but messy option to PVA glue, and acetate glue has safety issues including sniffing though acetate glue is useful for joining plastics and some fabrics. Hot glue is a useful adhesive that is suitable in construction and quick drying, however it has dangers associated with electricity and burns, as well as being expensive. Hot glue also can provide thickness to surfaces needing adhering because it does not soak into card like PVA, Clag or gum.

7.3 Wood and metal adhesive methods

Adhesive methods to join wood and metal include screws, nails, solder, nuts and bolts and rivets. Solder and rivets usually require and applicator. Screws, nails and nuts and bolts are usually applied with a specialist tool. Nuts and bolts usually require another operation before use such as drilling a hole or using a punch.

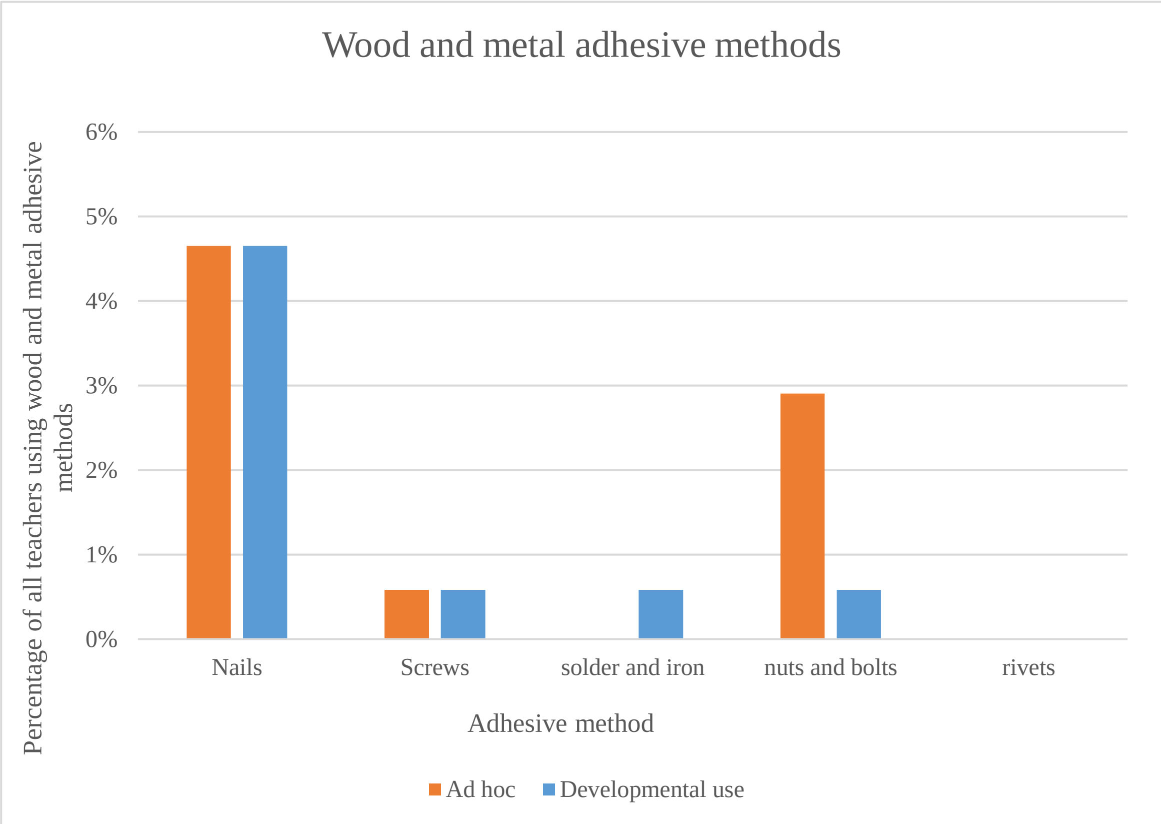

Figure 61. Wood and metal adhesive methods.

Figure 61 provides data on wood and metal adhesive methods. Nails are indicated that they are used by 5% of teachers in both an ad hoc manner as well as providing instruction in their use. The use of nuts and bolts in an hoc manner is indicated by 3% of teachers though during the interviews the sense was that these may have been used as a fine motor activity rather than a construction technique. This would possibly indicate why only 1% of teachers provide instruction in their use. Screws are used by 1% of teachers in both ad hoc and developmental instruction. Solder and rivets are not used in an ad hoc way by any teachers in the survey, but less than one percent of teachers indicated that they provided developmental instruction in the use of soldering irons. Rivets were not used in any fashion by teachers with children in the primary school.

7.4 Modern adhesive methods used in the primary school

Wearable fabrics and technology adhesive methods in this survey include pins, Velcro and 3D printing. 3D printing directly onto fabric is usually successfully done by interrupting the print after starting then laying the fabric over the top then continuing the 3D print.

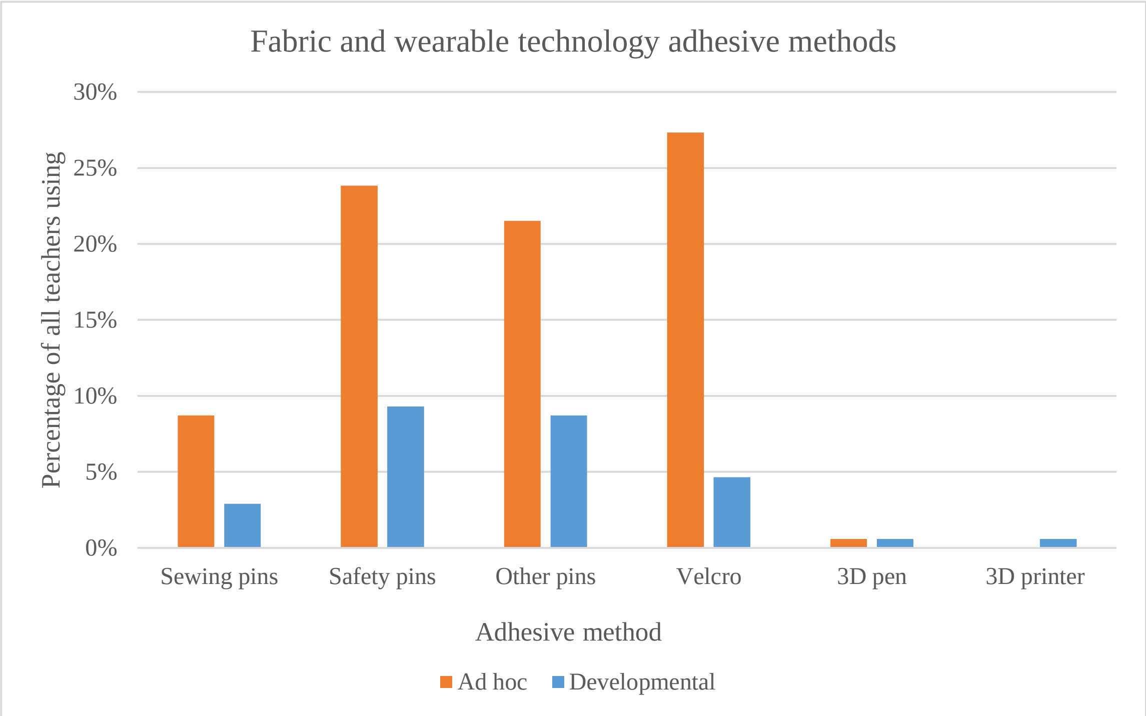

Figure 62. Fabric and wearable technology adhesive methods.

Figure 62 provides that Velcro is the most popular ad hoc adhesive method in this section with 27% of teachers using Velcro in an ad hoc manner whilst 5 % of teachers provide instruction in its use. Velcro has an interesting history related to space travel. Safety pins are used 24 % of the time for ad hoc events and are instructed by 9 % of primary teachers. Sewing pins can be a possible danger due to their open points which may explain their minimal (9%) use in an ad hoc manner by teachers and only 3% of teachers providing developmental instruction in their use. Other pins included thumb tacks, panel pins and push pins. Wearable technologies are a focus of twenty first century technology with interwoven electronics in fabrics becoming more popular and 3D pens and 3D printers adding new wearable design possibilities, yet they were used by less than one percent of teachers in their classrooms, either in an ad hoc manner or developmentally. Further, 3D printing directly onto fabrics adds depth and potential for incorporating wearable technology.

7.5 Ties used across the primary school

Ties used as an adhesive method in the primary school include, string, wire and plastic. Plastic ties and string used to tie corrugated cardboard may need an awl to use. Ties may be twist or pull through types. Wire ties maybe used in the garden.

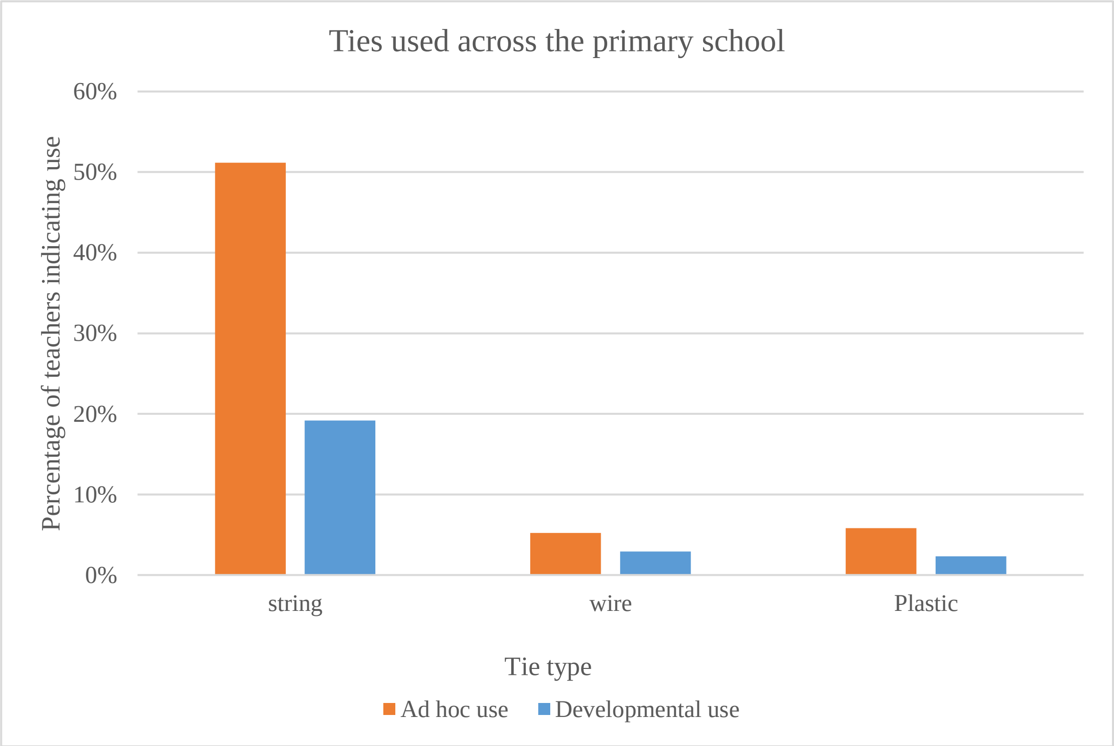

Figure 63. Ties used across the primary school.

Figure 63 shows tying methods used across the school with 51% of teachers indicating they provide ad hoc opportunities for children across the school whilst 19% indicate they provide instruction in the use of string. Plastic and metal ties are often used in design technology to attach components such as small direct current electrical motors to prototypes. Plastic and metal ties are used by less than 6% of teachers in the classroom.

7.6 Stationery adhesive items used in primary school

Stationery items found in the classroom include staplers and paper clips. Two types of staplers are the desk stapler and the plier stapler. Plier staplers may include a hand-held staple gun. Brass split pins are often used in primary school to form a fulcrum to allow two arms of a product to rotate.

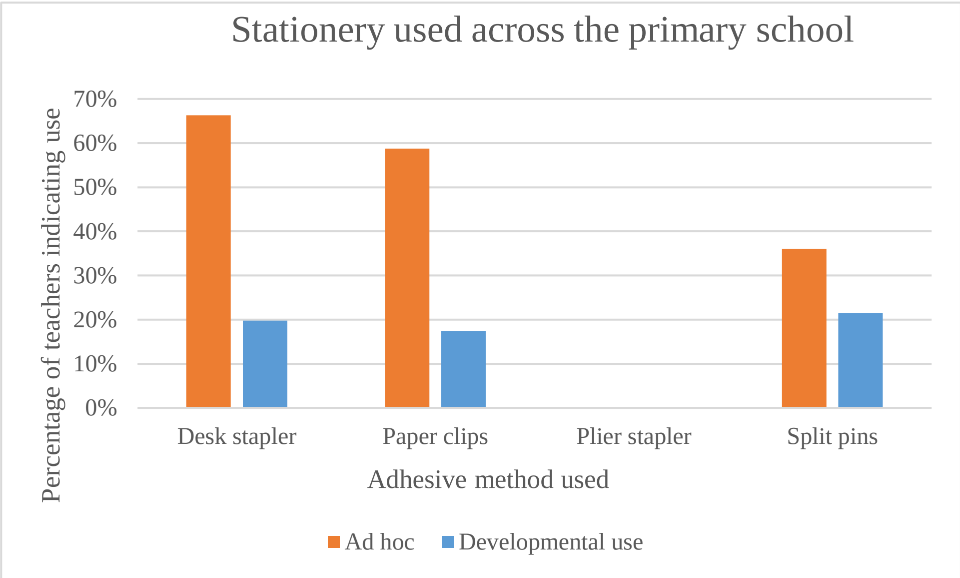

Figure 64. Stationery items used across the primary school.

Figure 64 identifies that the desk stapler is used by the most common ad hoc adhesive method in this section with 66% of teachers indicating its use in the classroom. However, only 20% of teachers indicate that they provide instruction in its use 59% of children are given the opportunity to engage with the ad hoc use of paper clips with 17% given instruction, Split pins have 36% ad hoc use and 22% instructional use. No teachers in primary school indicated that they use plier staplers. Plier staplers are useful adhesive methods for applying staples to a construction such as a newspaper tower where it is difficult to place the structure on a firm surface to operate the desk stapler.

7.7 Adhesive methods used across primary school

Adhesive methods are used in primary school across all year levels and for all discipline areas. The total number of opportunities to use adhesive methods in the classroom are recorded as well as the average number of opportunities per survey participant.

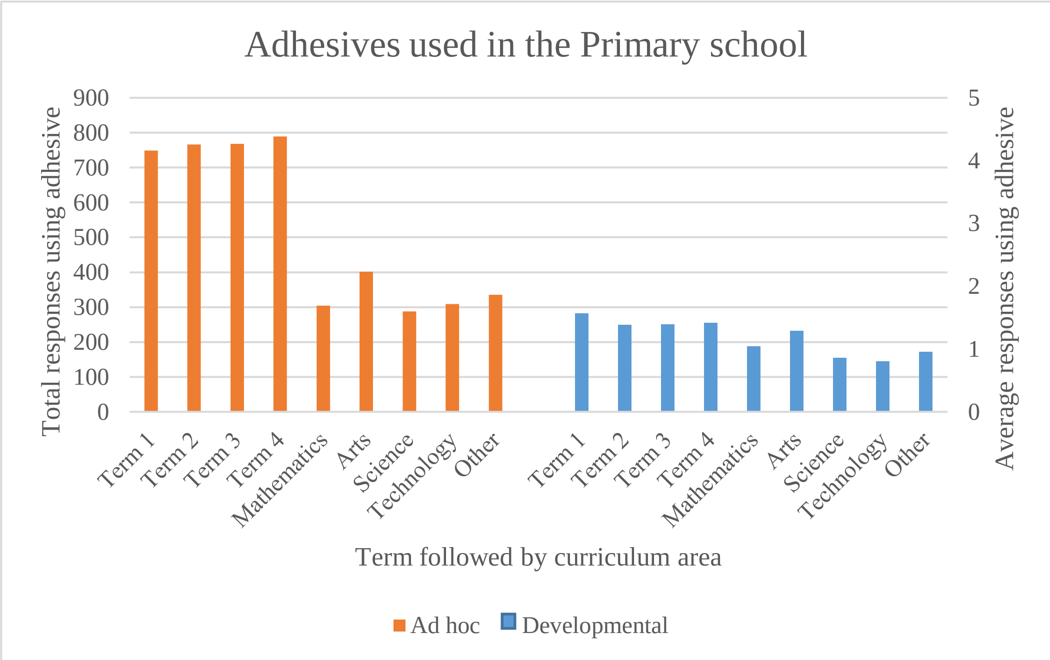

Figure 65. Adhesive methods used in the primary school.

The average number of opportunities for children to use adhesives in an ad hoc manner throughout the primary school year levels are shown in *Figure 65* with approximately five opportunities, whereas the average number of developmental opportunities drop to half of that. There does not seem to be significant difference in terms in the ad hoc use of adhesive methods and only a slight decrease in developmental opportunities. Arts was the area that had most ad hoc and developmental opportunities on average. Science had the least ad hoc opportunities provided for children whilst technology had the least developmental instructional opportunities.

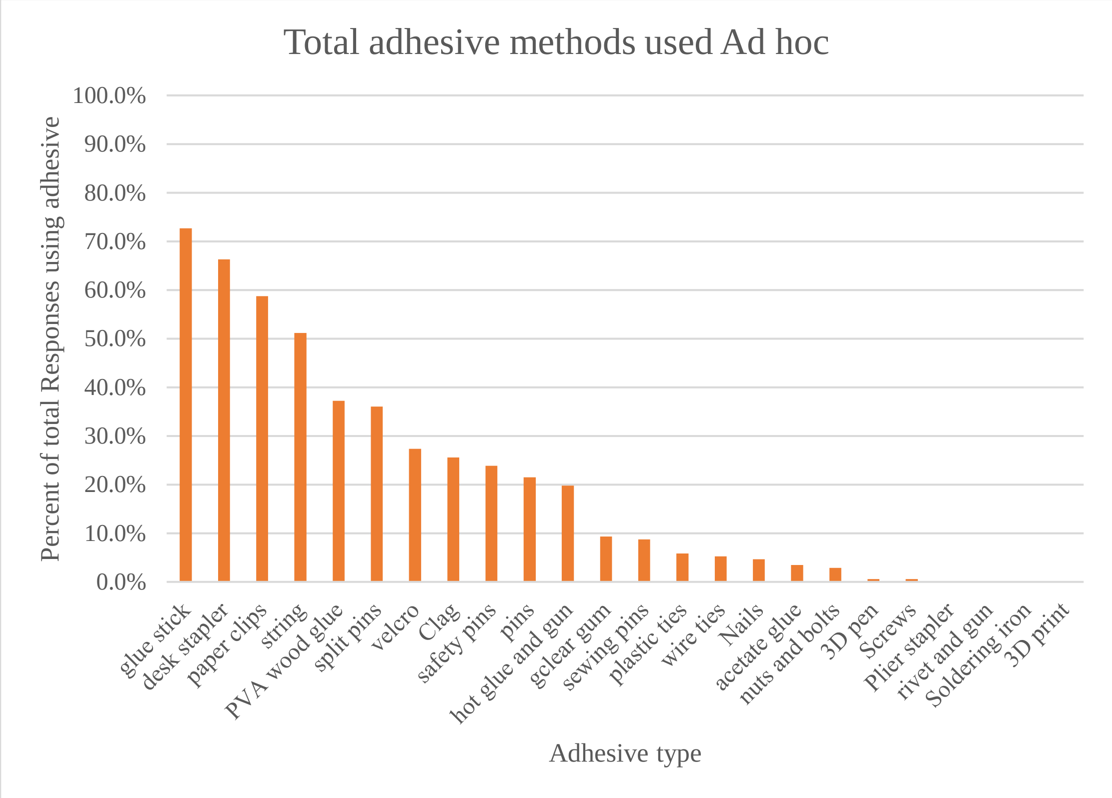

Figure 66. Ad hoc use of adhesives.

Glue sticks followed by desk staples were the most popular adhesive methods across the whole school as shown in Figure 66. Nails and nuts and bolts were once used from preschool onwards as indicated in the interviews. The expectation was that 3D printing and solder would be used in the upper primary classes as an adjunct to the introduction of Makerspaces in the primary school.

7.8 Adhesive methods using an applicator

Figure 67 shows those adhesive methods that use a tool to apply. Desk staples are applied by a stapler that uses force applied by the operator with support from a solid surface such as a desk or table. This contrasts to a plier stapler that uses the hand grip of the operator to apply the staple. Nails are applied by a hammer, screws by a screwdriver, rivets by a rivet gun etc.

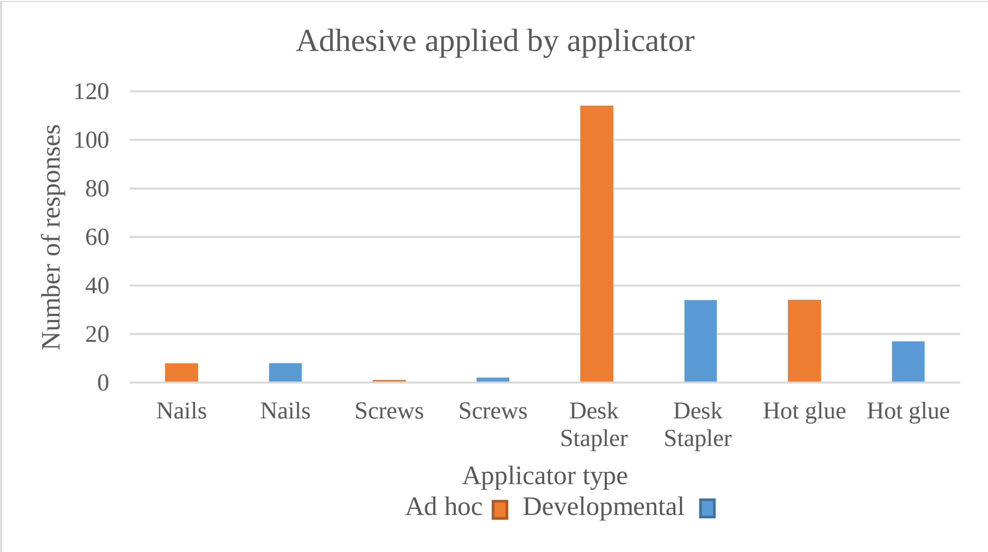

Figure 67. Adhesive methods using an applicator to apply.

As *Figure 67* shows the most used applied adhesive method is a desk stapler with 66% Ad hoc and 20% developmental, with the hot glue having 20% ad hoc and 10% developmental. The low use nails and screws indicates low use of hammers and screw drivers. The nil use of of tools to apply joining adhesive such as soldering irons, rivets, plier stapler, and 3D printers are not shown in the figure.

7.9 Chapter summary

This chapter focussed upon adhesive methods used in the primary school classroom. Adhesives considered those needed for paper, card, wood and metal. The data showed glue sticks and desk staplers were most used. In the following chapter, chapter eight, focuses on the data collected regarding confidence, training and the need for safety.

8 Safety and training

8.1 Introduction

The data in this chapter of the survey gives some interesting pointers to when and why tools, materials and adhesive methods are or are not introduced into the primary classroom. Confidence, training and safety are all linked. The understanding of safety, risk assessment, and work place health and safety by teachers has led to risk aversion in the use of tools, materials and adhesive methods in the primary school.

8.2 Confidence and safety

Most teachers indicated that they had average confidence with regards to tools materials and adhesive methods as shown in *Figure 68*. There were very low participant confidences in each section and very high confidences in each section with 88 participants indicating average confidence.

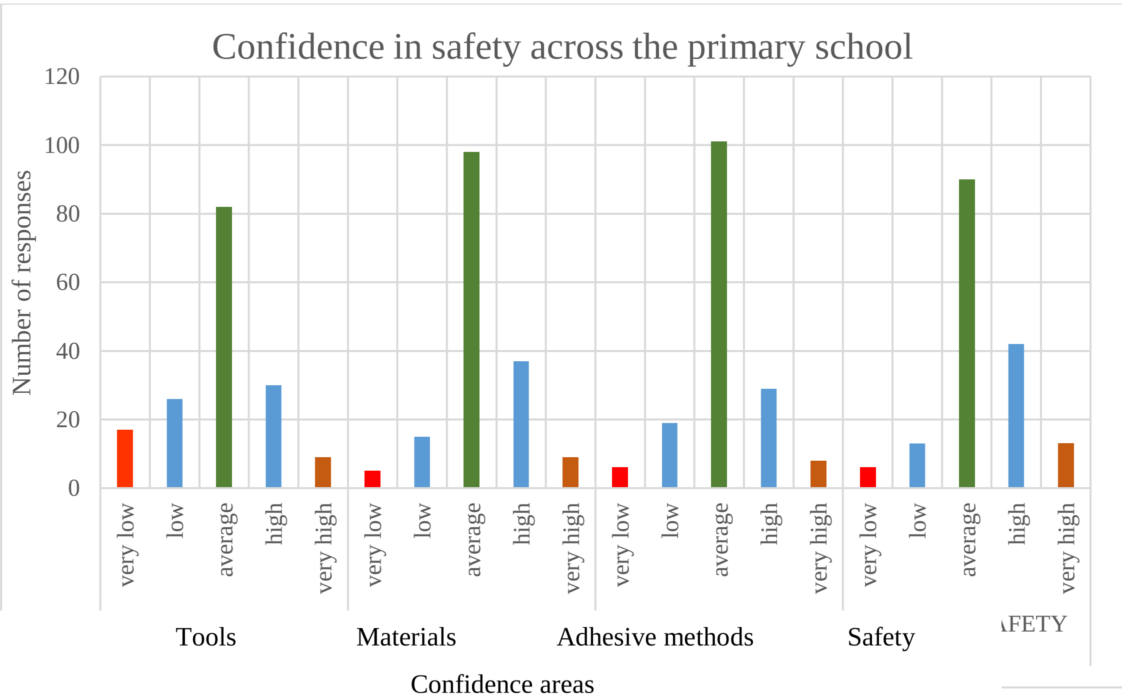

Figure 68. Confidence in safety across the primary school.

The total low numbers in confidence in the use of tools, as shown in *Figure 68*, was 43 responses made up of 16 very low and 26 low responses. There were 39 total responses in high confidence in use of tools made up of 30 high responses and 9 very high responses. The total low numbers in confidence in the use of materials was twenty responses made up of five very low and fifteen low whilst there were forty-six total responses in high confidence in use of tools made up of thirty-seven high responses and nine very high responses. The total low numbers in confidence in the use of adhesive methods was twenty-five responses made up of six very low and nineteen low whilst there were thirty-seven total responses in high confidence in use of tools made up of twenty-nine high responses and eight very high responses.

Data analysis of those who had responded in confidence in safety showed ninety teachers indicated average safety. The total low numbers in confidence in safety was nineteen responses made up of six very low and thirteen low responses whilst there were fifty-five total responses in high confidence in safety made up of forty-two high responses and thirteen very high responses.

8.3 Safety and training

Participants were invited to comment on safety and training they had received. Data was tabulated to consider training in the use of tools, materials and adhesive methods. Further the participants could indicate their in-service in the use of safety and commercial kits in the primary classroom.

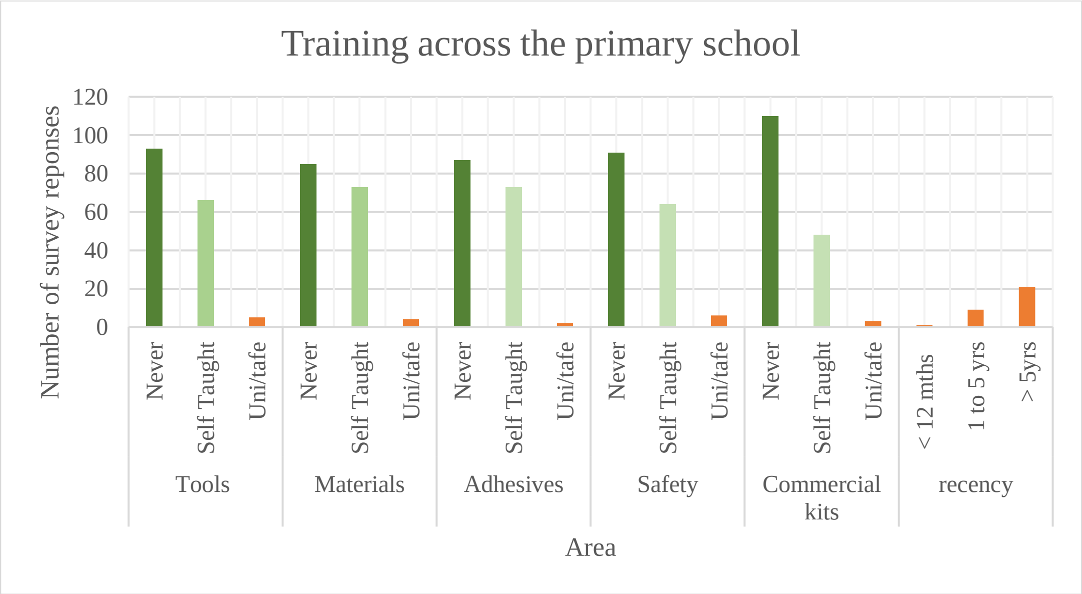

Figure 69. Safety and training across the primary school.

Figure 69 shows the total spread of training in tools, materials and adhesives used in the primary school with never the highest in each section followed by self-taught. Training in the use of tools, materials and adhesives was limited as shown by the results with training that did occur not occurring within five years. The training was highest in the area of greater than five years with twenty-one responses, and nine in the period of one year to five years. Only one teaching response indicating that they had done any training in the past twelve months.

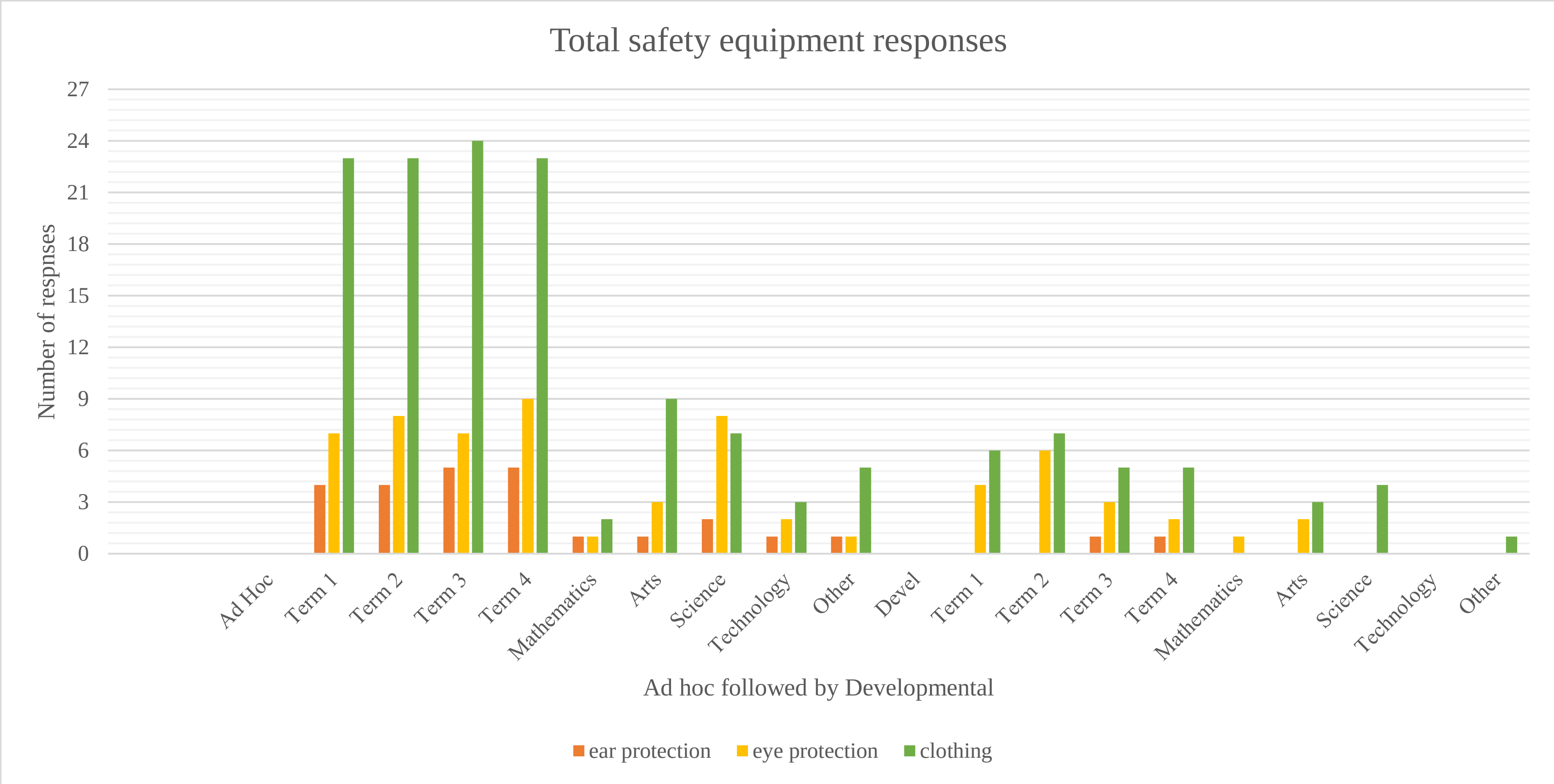

Figure 70. Safety equipment used across the primary school.

8.4 Safety responses across curriculum

Safety equipment for ear, eye and clothing represents a small percentage of teachers though shown as teacher numbers in *Figure 70*. Ear protection percent equates three percent in the ad hoc use of ear protection and zero percent in the developmental use in primary school. Eye protection is six percent ad hoc and five percent developmental and clothing is fifteen percent ad hoc and five percent developmental. The arts had the highest ad hoc clothing number and the rise in clothing percentages is partially expected, due to the use of aprons used in early years art lessons. There is no instruction or development opportunities in the wearing of safety gear in the subjects of technology and science, no safety goggles for example shown in the data.

Teachers have indicated that they have concerns regarding safety because of the lack of training that they have received or skill development,

> If the students were taught in the right way I don't think that it would be a huge issue they just need to be taught how to needs to be really explicit but in saying that it would also be very helpful if there were more bodies in the room like more adults in the room to assist to make sure when you are helping to make another student that the other one is not hurting someone else or hurting themselves by accident or probably the other part of it would be the furniture as well like we have brand new furniture in these rooms I wouldn't want there to be an issue with us cutting through to the tables because I don't think that would be so great because there's been so much money spent on the furniture and stuff. (Interview p. 60)

8.5 Comparison of teachers with very low and very high confidence in safety

An analysis of those participants that indicated very high or very low confidence in safety were compared to year level taught.

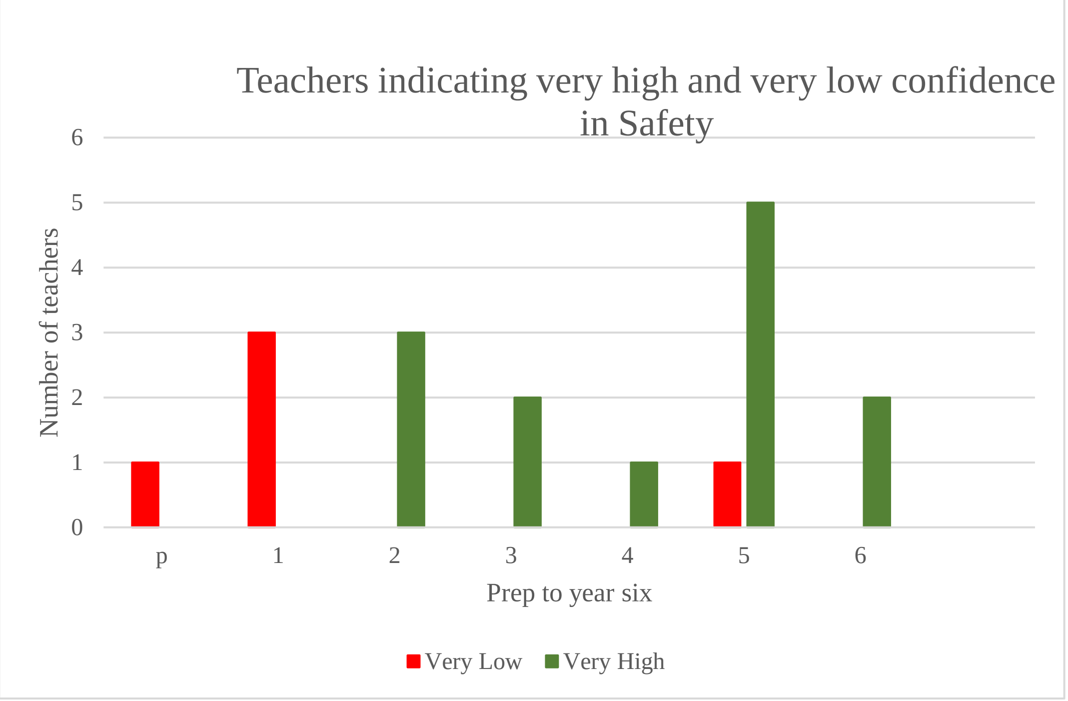

Figure 71. Teachers safety indications by year level.

Figure 71 shows teachers indicating very low or very high confidence in safety. Most of the teachers in the very low range of safety confidence range were in prep and year one in the very low range with one teacher from year five. In year two, three and four there were no teachers indicating in the very low range nor in year six.

There were no teachers in prep or year one that indicated a very high confidence in safety. There were teachers in each year level from year two to year six that stated that they had very high confidence in safety.

8.6 Training and skill development

The numbers of teachers engaging with professional development in skilled use of tools, materials and adhesives are limited in the main to self-taught or never having been instructed as shown in Identifying how tools are developed across the school year a comparison of tools by year level is made as in Figure 35. Tools are grouped by year level and by bands as per the Australian Curriculum. Prep to year two, year three and four, and years five and six, are the bands associated with the primary school curriculum. The trends of most of these tools across the primary years from prep to year six was a decline in use, as in the examples of safety scissors and paint rollers.

Each teacher responding to the survey indicated whether they used tools in a developmental (De) and Ad hoc (Ah) manner or both, followed by which term they used the tools, and finally the curriculum area that the activity the tools are most used with (MASTO – Mathematics, Arts, Science, Technology or Other).

To identify and collate the data the tools data was organised by year level then a formula was applied in Excel to add the total number of teachers indicating each tool to gain a percentage. Therefore, a hundred percent in a table represents only those teachers in the band not a hundred percent of the teachers responding to the survey.

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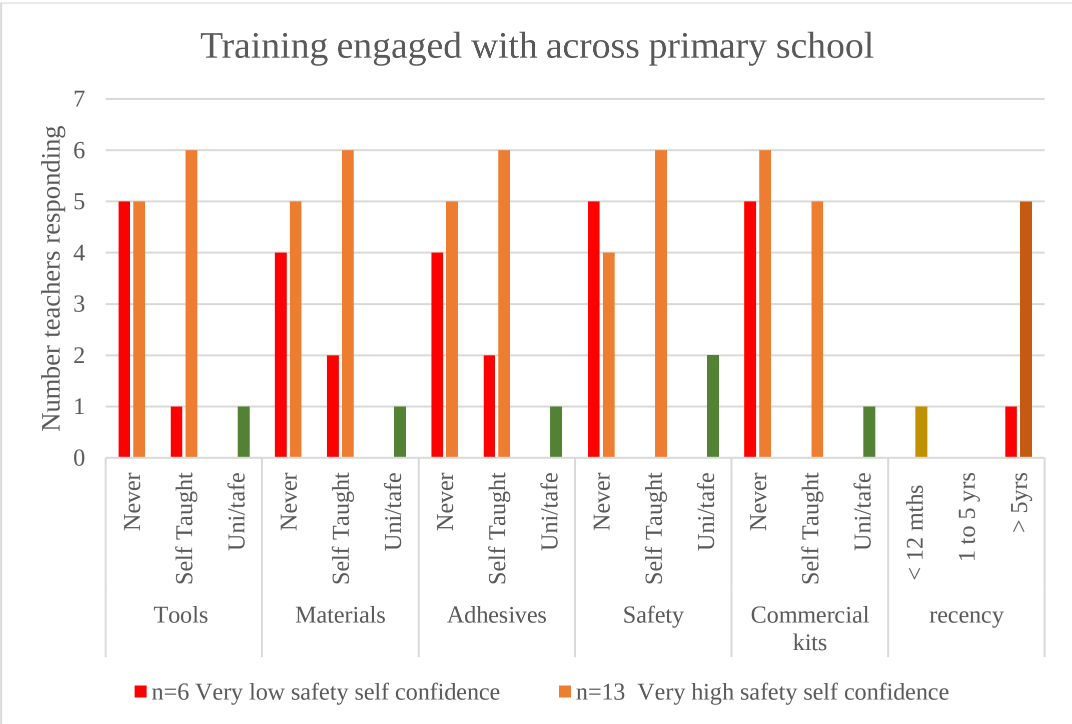

Figure 72. Teacher professional development.

Figure 72 identified in the survey data teachers with very low safety self-confidence (n=6) and those with very high safety self-confidence (n=13) and compared their training. All of the responding teachers were self-taught or had no training with more in every category having had no training in the use of tools, materials, adhesives, safety or the use of commercial kits. Whilst the majority of teachers in the very high confidence were either self-taught or had no training there were more teachers that had self-taught. The only teachers that indicated that they had had some training from TAFE or university were those in the very high self-confidence in safety.

8.7 Confidence in tools, materials and adhesive methods

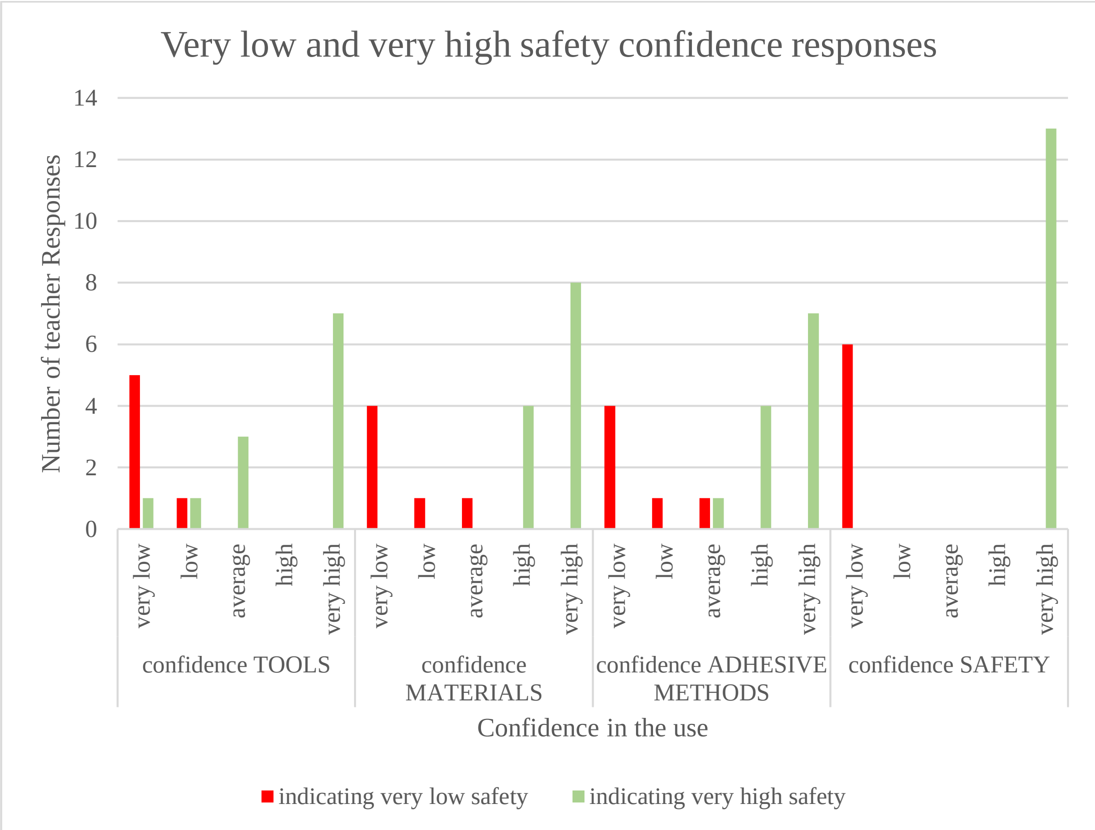

Figure 73. Comparison of very low and very high safety confidence responses.

In *Figure 73*, teachers in safety confidence that were very low or very high were tabulated with 11% of total teachers represented. There were thirteen (8%) very high to six (4%) very low. Of the thirteen very high confidence in safety overall one felt very low confidence in the use of tools, one low in the use of tools, three average, none high confidence in using tools and seven very high confidence in using tools. The six in very low safety confidence were all in the very low to low confidence in tools.

In the confidence in materials the very high safety teachers were in high to very high. The very low safety confidence teachers were all in the very low to average confidence range. This pattern was repeated in the adhesive confidence section.

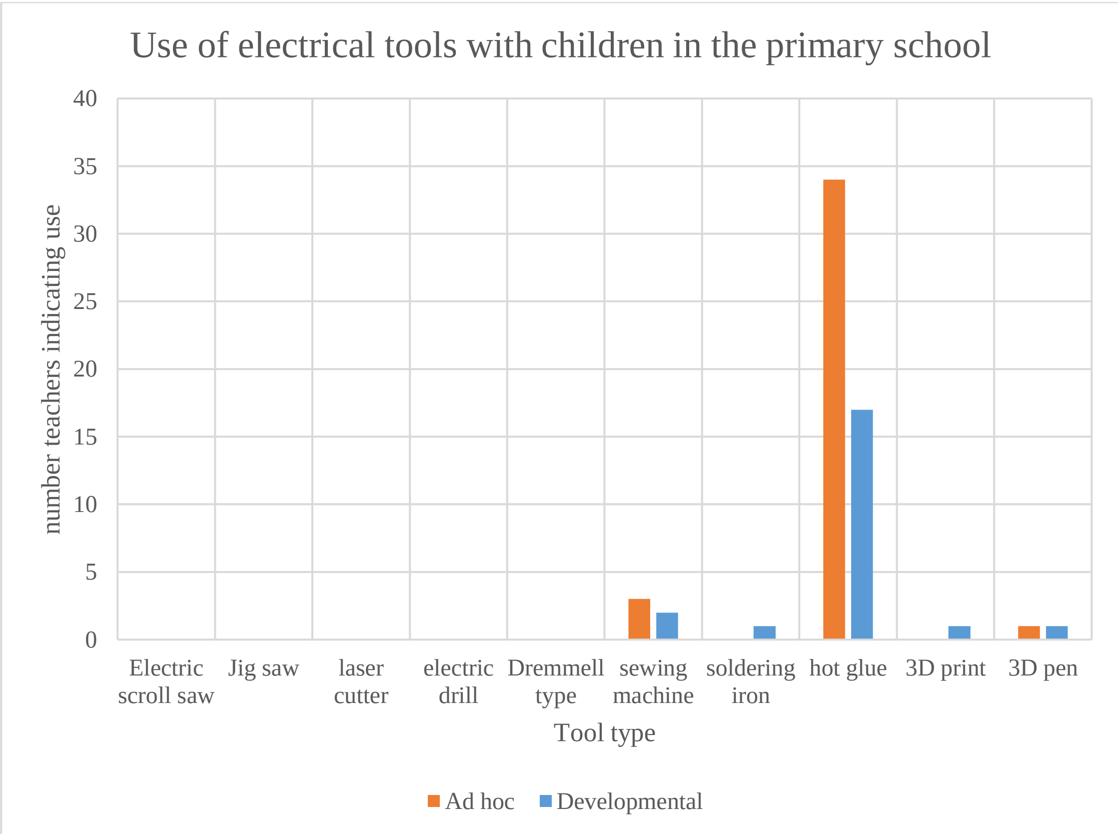

Figure 74. Safety and the use of electrical tools.

Many teachers cited safety for the lack of use of electrical tools in the primary school as highlighted in *Figure 74*. With thirty-four teachers indicated that they use hot glue with children in the classroom it is difficult to see why some of the other electrical including battery operated tools are not used. Some teachers indicated lack of training, “I am not confident I would need to be in-serviced” (Interview p. 85). Whilst others cited safety concerns with size and behaviour of children in the classroom, “we don’t have the right ratio of students to teachers” (Interview p. 77). Also, “safety … you can’t be everywhere … to make sure everyone is being safe …

big behaviour issues in class like with the use of the hot glue gun, we didn't let the kids touch them" (Interview p. 57).

The only electrical tool that had more than two teachers indicating that they provide developmental instruction across the primary school was hot glue guns. The expectation when using tools in an instructional manner was the children learning to use them safely and effectively yet from some of the interview responses it seems that the teachers may show the children the hot glue gun in use but not actually let them touch it.

8.8 Chapter summary

The area of safety data within this research survey was small but it highlighted important ideas. Teachers are not being in-serviced in the use of tools, materials and adhesive methods. The early primary school years teachers were the ones whose confidence in safety was the lowest. An analysis of the teachers in very low confidence averaged fourteen opportunities for children to engage in an ad hoc manner with tools materials and adhesive methods the same as those with the very high self-confidence. Surprisingly though, the teachers in the very low self confidence in safety also provided on average fourteen opportunities for development and instruction for children in a year, whereas the very high self-confidence only provided on average six opportunities for children. So, while the very high self-confident teachers were very safe in their self-confidence for safety, they did not instruct nor develop as many tools, materials and adhesives as the very low self confidence in safety teachers. Instruction needs to be provided for teachers in the use of tools, materials and adhesive methods.

In endeavouring to protect children from all and any mishaps teachers are not introducing any materials nor adhesive methods into the classroom that are new or novel or that they do not feel comfortable with. This is especially so with tools such as hot glue guns and Stanley knives.

An in depth look at some tools, materials and adhesive methods from the data above will be the focus of chapter nine. These will include tweezers, glue sticks, hot glue, scissors, Stanley knives and wood.

9 Analysis of specific tools, materials and adhesives identified in the survey

9.1 Introduction

This section will further investigate the use of selected tools, materials and adhesive methods that are indicative of the development of fine motor skills. Fine motor skills are those skills associated with using small muscles in the operation of hand tools such as tweezers, scissors, single hole punch, mathematical instruments and staplers. Some of muscle groups are finger, hand, wrist and arm control along with eye coordination. Using scissors require finger, hand and wrist control along with eye coordination. Henderson and Pehoski (2006) stated “The hand is also used to gain information about other object properties such as texture, hardness, size, weight, and spatial orientation” (p. 65).

The tools selected are safety scissors, Stanley knives, and tweezers, whilst adhesives will be glue sticks, hot glue, materials will be wood. Safety scissors and glue sticks were not the first choice as they were most commonly cited however the use of glue sticks and scissors across all the year levels made them prime examples of what was being used on a regular basis in schools.

9.2 Tweezers

In the initial data collection, the number of teachers highlighting tweezers were identified by this researcher as an unexpected. Tweezers were used by thirty-one teachers in an ad hoc manner and twenty-two teachers indicated that they provided some instruction in the use of the tool. The use of tweezers in the primary school indicated that there were two types, those that used force to close and grip and those that used force to open and release, and usually made of plastic or steel. Most of the tweezers used in the primary school were of the first type and made of plastic. Interestingly the use of tweezers as a tool changed in function across the primary school years. In early years tweezers were used to assist in the development of fine motor control and strength. (Council, 2008, p. 4; Hendrick, 1994)

> We have games with like the tweezers, the plastic ones, and things like pom poms or toys and pick them up and put them in containers; really it’s just developing that control and then you might swap hands and the non-

> dominant hand might be used or put your hand behind your back, things like that develop fine motor control. (Interview p. 1)

"When I had year one, we used to do like picking up" (Interview p. 45). In these years the squeezing effect of the tweezers to pick up an object is about strengthening the fine motor muscles and developing control.

In later years the focus was on using the tweezers as a method of selecting and placing specimens, "Tweezers to pick up specimens" (Interview p. 88).

> Really at the moment the only thing we are using to develop fine motor skills is scissors with the technology unit we just did, even using things like screws and trying to hold into things they were using screws still using tweezers, for some things, but other than that we don't use anything much not really. (Interview p. 67)

Tweezers are also used in positioning fine components and for setting components in difficult to reach spots such as electronic circuits and for disassembling and tinkering.

> Tinkering is an important element of the maker movement that is sweeping the country in schools, libraries spaces and museums. This movement is driven by people 's desire to create something with their hands. Children love to take things apart - a process known as deconstruction. (Heroman, 2017, p. 73)

Stewart, Rule and Giordano in using an experimental treatment design with "a series of supplemental fine motor activities in which children used tongs, tweezers, and spoons to move small items" (p. 103) It should be noted that "Providing interesting activities, choice in activities, and choice in how to complete activities improve children's persistence and thus attention to the task" (Stewart et al., 2007, p. 107).

Other teachers indicated that they once used tweezers but not now, "No, we don't use tweezers ever, not at all I know that in prep and year one we used to, do like picking them up with it but not now not so much" (Interview p. 45).

9.3 Glue sticks

Glue sticks have become the adhesive method of choice for primary school. They are easy to store and use.

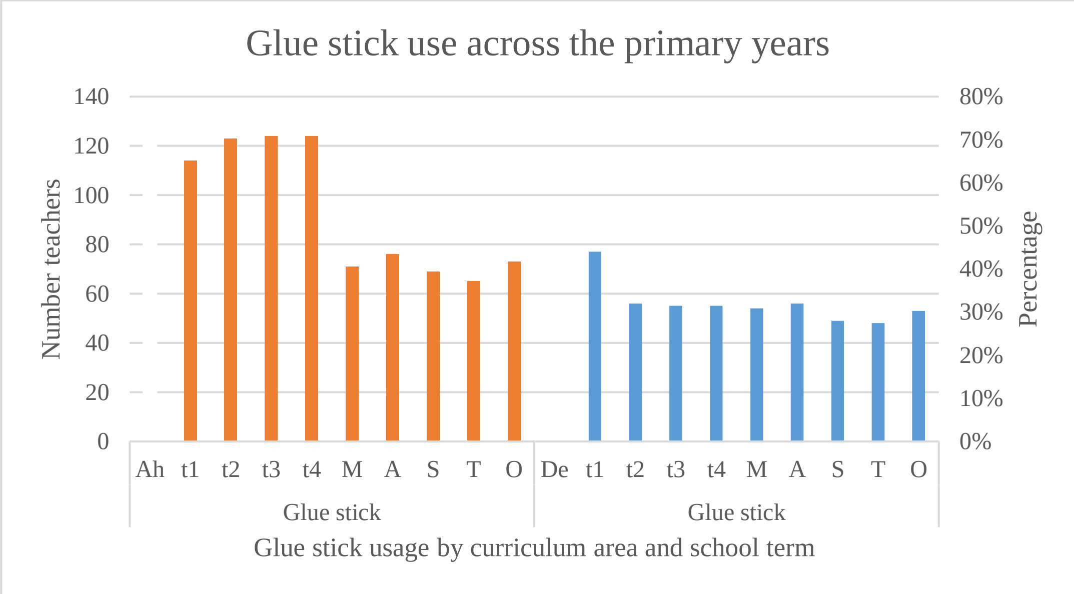

Figure 75. Glue stick use across the primary school.

Glue sticks were the most popular adhesive method and used across all the year levels with ad hoc use at seventy three percent and developmental use at forty five percent as indicated in *Figure 75*. The glue sticks were used across all school terms and subject areas with no discernible pattern and because it was safe and non-toxic, “prep kids eat the glue – they eat the glue sticks” (Interview p.19) and

> Because that is the quickest and easiest way to get work sheets and things glued into books and that’s what we usually do especially with our clientele being a lot of overseas (children) there is a lot of gluing in of things that try and assist them in their reading or definitions or extra pictures or things like that the glue stick is used for that but obviously we wouldn’t be able to use that when it came to gluing wood together or boats or anything like that and the other part of it would be resourcing because we ask the parents to pay for glue sticks whereas everything else the school funds when it comes to gluing things together. (Interview p. 58)

The issue of school resourcing comes to the fore around this consumable item with teachers indicating that “the kids” (Interview p. 46) supply the glue because “that’s what’s on the school booklist basically, there’s that one (…) that sort of glue is just purely for gluing sheet in and that sort of thing" (Interview p. 69). Even though it is the most common adhesive used there are some concerns by the teachers regarding the use of glue sticks, "Easy non-toxic I don't think we use it properly though and I think it is a taught skill because when I taught year 1 and even now they don't just do the edges and the middle it's like a whole glue stick on a page so but it's easy and non-toxic and its cheap material as well" (Interview p. 45). The use of glue sticks to glue in sheets of paper would also support the most popular material to be used which is A4 photocopy paper. The cost of and accessing adhesives and other resources in primary schools is raising a theme point here, funding and budgeting and requisites supplied from home. Further, "because they are simple and easy to use, they are not necessarily effective but they simple easy to use safe" (Interview p. 78) indicates that the effectiveness to adhere in all situations is also limited.

> I try and teach the kids this each glue that they have so in their desk they have they have glue sticks which are good paper to paper, if they want to do cardboard or wood then PVA glue works better but takes longer time to adhere and also absorbs into the cardboard and makes it less rigid and I find acetate glue works for me because its instant and its and if I want something that can really rigid kind of construction for example like a box that they are making with a lid, PVA glue would make it bow in the corners whereas acetate glue makes it glue quite easily they can get the corners and they can put the lid on within 15 minutes because it dries almost instantly. (Interview p. 101)

Another teacher laments that by using the glue sticks that other skills are also lost, "putting the whole idea of putting a brush in the glue wiping it – about the volume of glue I need – all those problem-solving skills" (Interview p. 27).

The booklist is sent out at the end of the year so that the resources are ready for the beginning of the new year. An online search of publicly available state school book lists for year four or five shows the 2018 book lists asking for four, five up to eight glue sticks. These glue sticks are generally collected and stored by the class teacher.

The use of glue sticks is also demonstrated in the standards of the Australian Curriculum for prep to year two in the design subject of the technology curriculum.

Here the foundation year level student is assessed as being above satisfactory in the working safely use of tools where it is stated “Demonstrates gluing paper to paper safely using a glue stick” (Australian Curriculum Assessment and Reporting Authority, 2018f).

9.4 Using hot glue

The Australian Technologies Curriculum has two subjects, Design and Technologies and Digital Technologies. These subjects are presented in bands in primary school; Prep to year two, Years three and four, Years five and six. In the Rationale for each of the band descriptions is the following suggested developmental sequence from the design and technologies subject:

> In foundation to year two the students plan (with teacher support) simple steps and follow directions to complete their own or group design ideas or projects. Year three and four band students become aware of the appropriate ways to manage their time and focus, and with teacher guidance, they identify and list criteria for success including in relation to preferred futures and the major steps needed to complete a design task. Year five and six students work individually and collaboratively to identify, and sequence steps needed for a design task (Australian Curriculum Assessment and Reporting Authority, 2014f).

The sequence suggests a developmental progression that includes moving from teacher support, with teacher guidance to working independently. Further there is a progression in developing safety standards and practices when making designed solutions. This added to the sequence of content descriptors in bands of the Australian Curriculum which state –

> Foundation to year two ;(ACTDEP007) Use materials, components, tools, equipment and techniques to safely make designed solutions

> Year three and four;(ACTDEP016) Select and use materials, components, tools, equipment and techniques and use safe work practices to make designed solutions

> Year five and six; (ACTDEP026) Select appropriate materials, components, tools, equipment and techniques and apply safe

procedures to make designed solutions. (Australian Curriculum Assessment and Reporting Authority, 2014c)

This progression reinforces the notion of the growing capability of students to engage with tools safely from tools used from the earliest years through to year six.

Hot glue and glue guns are specifically mentioned in the Australian Technologies Curriculum, in both the Foundation to Year 2 Design and Technologies portfolio – Above Satisfactory and Satisfactory exemplars for working safely, as shown in Figure 76. Because the image is difficult to read a transcript follows.

Figure 76. Safely using hot glue.

(Australian Curriculum Assessment and Reporting Authority, 2018e)

Students demonstrate working safely to produce designed solutions. In the left image of figure fourteen, the above-satisfactory exemplar, the student sequences all steps for using a hot glue gun safely in the correct order. Whilst in the satisfactory exemplar (on the right), the student sequences most steps for using a hot glue gun safely in the correct order.

The steps listed on the paddle-pop sticks are

1. Ask an adult to supervise
2. Work with a partner
3. Put a heat proof mat on the Table
4. Check the glue gun has a glue stick
5. Put the glue gun in the stand
6. Turn the power on
7. Wait five minutes for the glue gun to heat. If there is too much glue don’t squeeze so hard
8. Test on a spare piece of wood
9. Gently squeeze to see how fast the glue comes out
10. Squeeze the glue gun safely to glue materials
11. Switch off power
12. Wait until the glue gun is cool before packing away.

(Australian Curriculum Assessment and Reporting Authority, 2018b)

This would indicate that glue guns and hot glue are used by the children from the earliest year levels and that development in the safe usage of hot glue guns and glue would be highest in the early years. Therefore, the hot glue use is a useful adhesive to map when it is introduced into the primary school at what years and terms, with what materials and safety. Further, in line with children accepting more responsibility and teachers providing less scaffolding previously mentioned, hot glue usage would be more ad hoc in the upper primary school year levels as the students become more confident and safer with using the adhesive.

Interestingly these ‘above satisfactory standards’ from the Australian Curriculum, in the safe use of hot glue do not indicate that a) the child should not touch the pointy end of the hot glue gun as it gets very hot, b) not to touch the hot glue as it comes out, and c) not to place the hot parts of the glue gun on the electrical cable. Secondly the ‘satisfactory standard’ in safety indicates that the child has most of the paddle-pop sticks in the right order but does not indicate what order that might be nor which ones may be put in the incorrect order, for example what if point 5 from the sequence above was placed first.

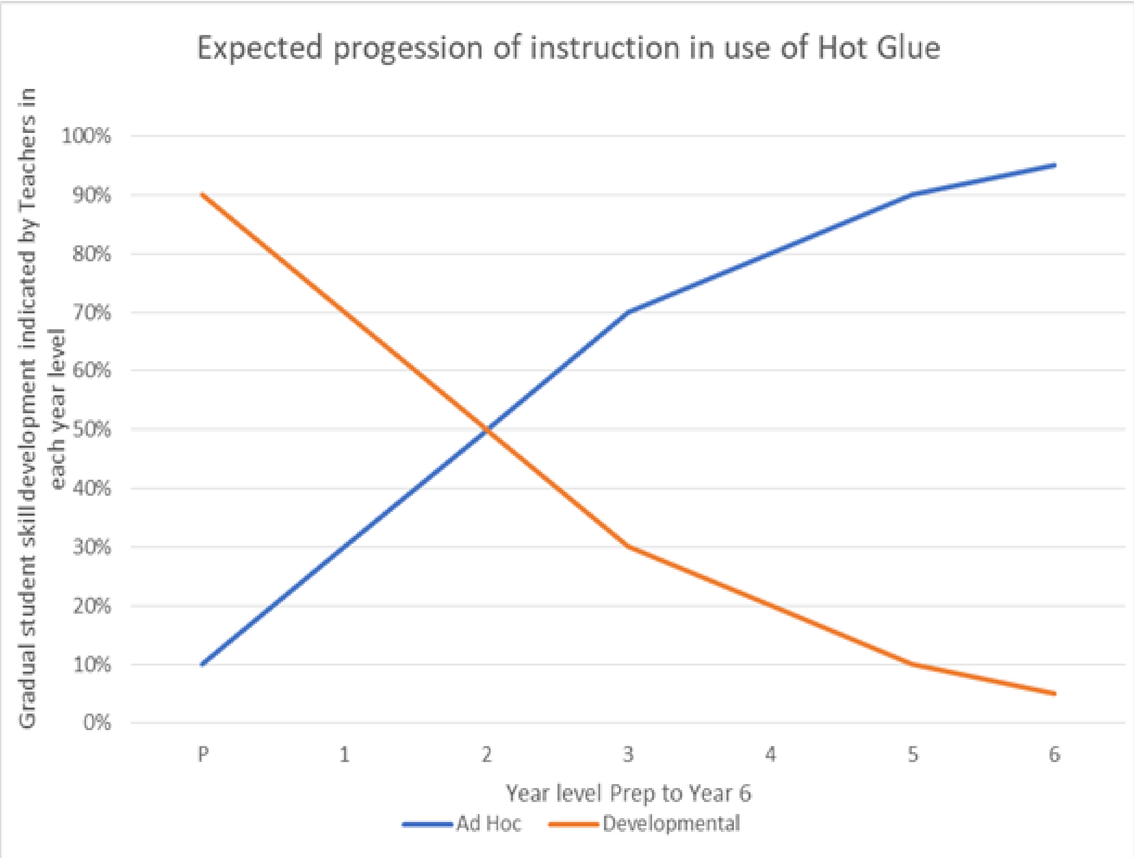

Figure 77. Hot glue usage from prep to year six.

The survey data in Figure 77 did indeed show a reducing progression of developmental instruction in children using of hot glue with an increasing ad hoc use over the primary school years by teachers indicating that they used a hot glue gun with the class. However, analysis of hot glue and glue guns use in the primary school show that only ten percent of all teachers in the survey indicate that they directly teach developmental skills in the use of hot glue guns and hot glue, whilst twenty percent of teachers use hot glue in an ad hoc manner with in the primary classroom.

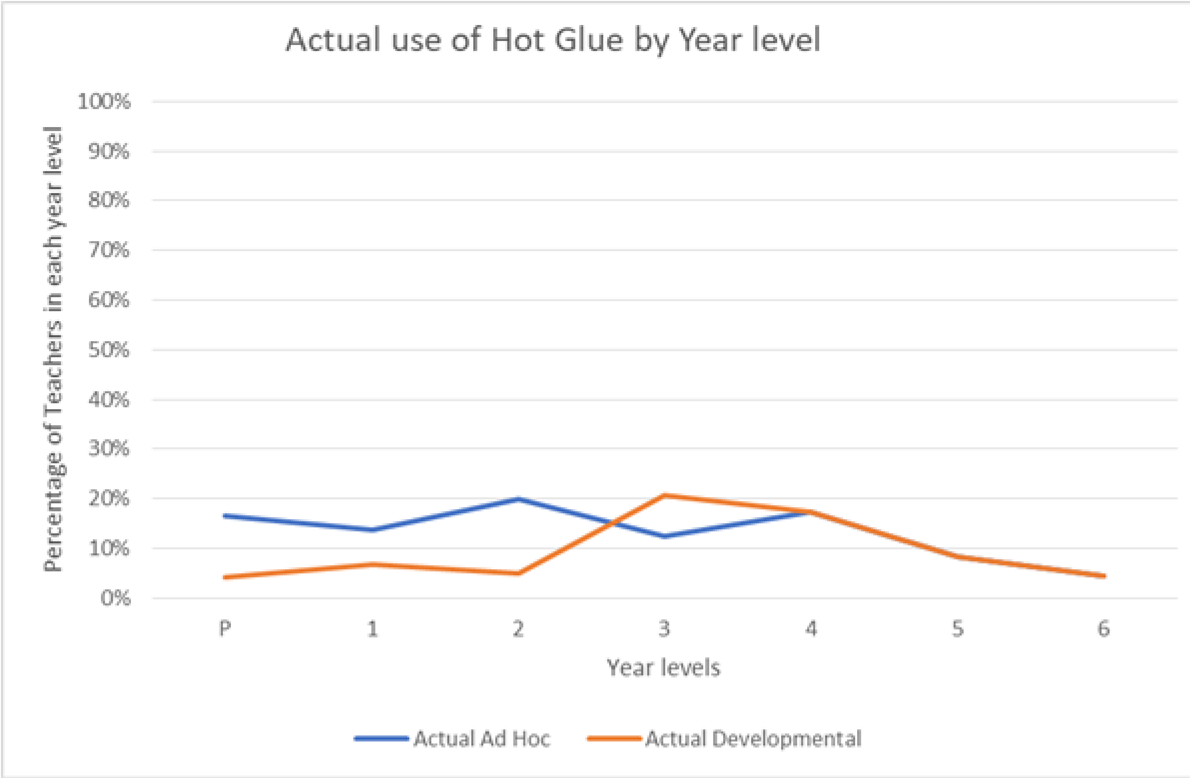

Figure 78. Percentage use of hot glue from prep to year six.

Figure 78 shows the actual percentage of teachers indicating the use of hot glue across the primary school from prep to year six with a comparison of ad hoc and developmental with developmental instruction peaking in year three. The ad hoc use reflects that the hot glue is used in these classes, but the interview data indicates that it was not used by the children in an ad hoc manner rather hot glue was applied by teachers or teaching assistants.

From the survey data Figure 79, shows the most common curriculum areas indicated that the classes use hot glue are as follows was The Arts (32%) followed by Mathematics and Technologies, each (18%) with science registering fifteen percent of total subject usage. The interview data provided insights why this was the case and also that whilst the teachers may be using hot glue and instructing students to use the same safely there was a reluctance to allow the students to use the glue directly.

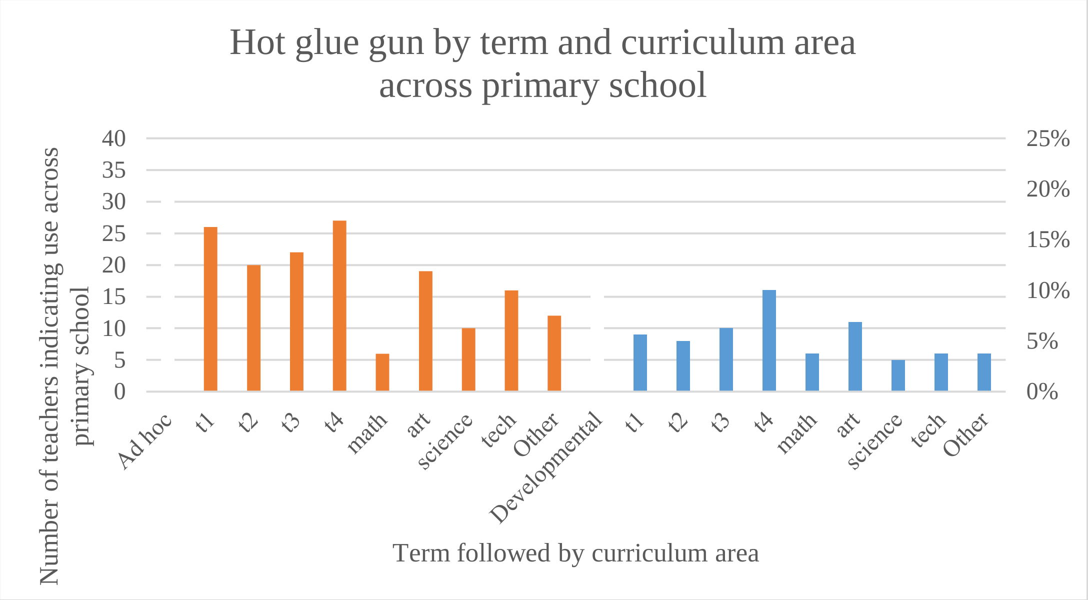

Figure 79. Hot glue by term and curriculum area.

Figure 80 shows the proportion of discipline areas where teachers indicated they provided instruction in the use of hot glue. The main area of use was arts with thirty two percent. Mathematics (17%) and technologies (18%) had a similar amount of usage to an undefined other (18%).

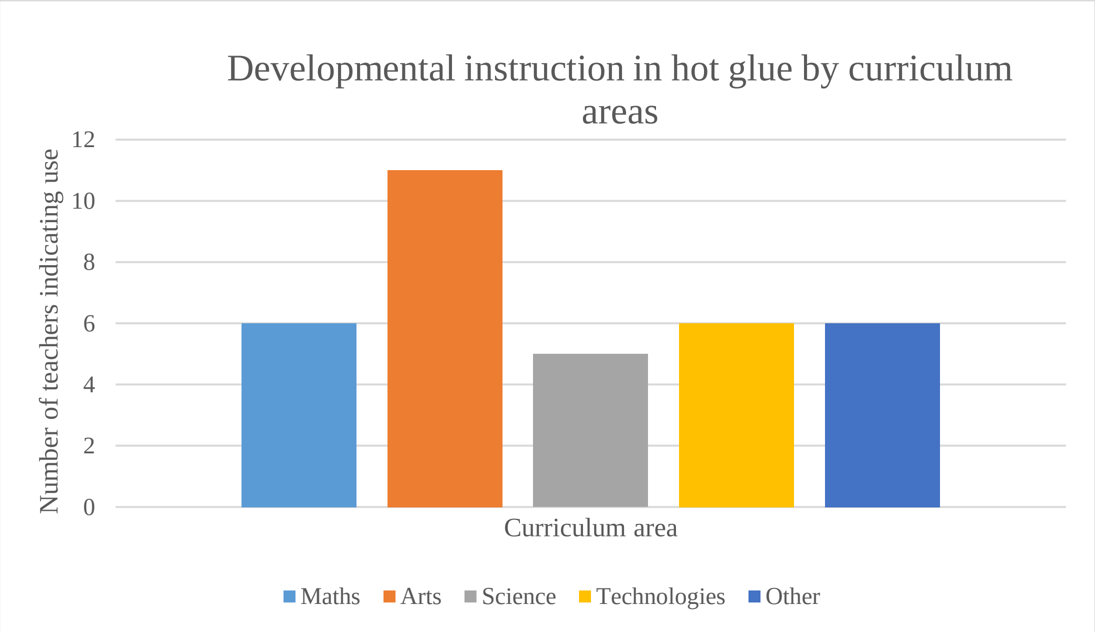

Figure 80. Developmental instruction in the use of hot glue by curriculum areas.

In the qualitative interviews following the survey, some suggestions came to light as to why this may be the case. These included safety, time, resources, and professional skills and knowledge. Safety of the children was paramount in the minds of all teachers. Safety regarding adhesive use included managing behaviour, resources available, and skills of the teacher. “Hot glue and things like that but I, we (sic) didn’t let the kids do them, we actually did the hot glue and we sort of got the teacher aides to help us do that as well” (Interview p. 69). “I think trusting the kids, mess and also, we only had two hot glue guns and I think it was more of a time thing it was quicker for teacher aides or us to be doing it rather than kids” (Interview p. 69).

> Safety too for hot glue guns I probably think that we don’t have the time to teach the kids to use this stuff the whole time you know and its sort of like well do that and you’ve just got to get the thing built the whole time whereas they probably should be practising how to use a glue gun and practicing how to use screwdriver or whatever they are going to use and we don’t have the time to do that. (Interview p. 72)

Teachers indicated that time for instruction and practice was not available. Teachers felt that supervision needed in small groups and this was not available, “And the practice is coming in there it’s not just the learning but opportunities for practice” (Interview p. 7). “I think part of it might be its also the safety thing … I had the teacher aide on the glue guns” (Interview p. 57).

> I have to do it myself , I just find like recently we just did something that I have done in other years having looking at recycling making craft form recycling materials and in other years I’ve done the same activity with the help of a couple of aides, maybe a couple of parents so that each group could work with an adult and it meant using acetate glue and hot glue gun and a whole variety of different things but last week I had to I tried this I had four crafts by myself and in the end nothing got completed because there were all bits and pieces and I spent the entire week in pulling kids out of a (specialist lesson, non-contact time, NCT) and library before school just to try and finish off that craft and in the end there are still children that have got pieces that aren’t finished and next week we are supposed to be doing it all again so it impacts on me hugely because I’m alone having to do this whereas before I was being fully supported and I can see why people don’t do as much hands on things because it becomes incredibly stressful. (Interview p. 106)

This teacher indicated the importance of support and assistance in completion of a task when making a craft product with multiple parts to complete, and children at different levels of completion. This also indicates the importance that the teacher places on children actually completing the task. The teacher further indicates the stresses involved in not completing the task may reduce future opportunities to attempt similar activities.

> I think definitely depending on the tool some teachers would avoid it because they're not comfortable because they don't have the skills to deal with it where they're from - I mean hot glue is one that springs to mind so and generally what has been indicated is teachers would not use hot glue guns with children. (Interview p. 93)

The teachers indicate several issues related to time with glue guns including preparation time, instruction time, practice time, as well some issues related to supervision, storage of products and cleaning up after making a product. Teachers indicated that lack of assistant support during hands on activities as being a major indicator regarding safety, "Because, all our teacher aide time is now straight into our literacy and numeracy blocks, so we rarely have teacher aides supporting us during those times that are messy" (Interview p. 78).

9.5 Using scissors

Tools are used to manipulate materials and do so in a variety of ways including, resizing or reforming. Resizing may include cutting, slicing, folding. From the data in this study, the most common tool used for cutting from prep class to year six is safety scissors. Safety scissors are so called because of the short blade length (about one hundred and fifty millimetres in length) and the rounded blunt end at the point meaning that it is less likely to cause a puncture wound if inadvertently pushed into a body part; such as a child cutting their own hair and not pushing the point into their scalp. Some of these scissors are called blunt scissors because of the rounded ending rather that blunt edges. Some blunt safety scissors are so called because the blade is blunt and specifically designed to only cut paper.

Many of these types of scissors have plastic blades. These scissors can cause great frustrations by the user as in this still from a short video shows, of a year two child trying to complete an activity on ancient Egypt. The activity organised by the Queensland museum was using newly purchased, plastic safety blunt scissors.

The child laments "It's not cutting, it's not cutting, it's not going to cut (takes another pair of similar scissors) it's not cutting (Year two student)," and it doesn't, because the thin card bends in the scissors as shown in *Figure* 81.

Figure 81. Plastic scissors causing card to bend rather than cut.

Some safety scissors are sharp and designed to cut a variety of materials including tape and fabrics. There is not one specific definition for safety scissors, however teachers in foundation to year six recommend the type of safety scissors that have a rounded nose with sharp blades to enable cutting of card and material as well as paper. Further, Warnick (2014) suggested “Weak, dull tools can be frustrating and sometimes more dangerous” (p. 27). A programme of developmentally introduced skills using scissors may include snipping, non-snipping, cutting broad straight lines, thinner straight lines, curved lines including convex and concave lines, progressing to circular shapes, then combination of line cutting progressing to complex shapes such as teeth and gears. At the same time as cutting for a purpose there is developing and strengthening the hand muscles to allow successful cutting and increasing accuracy and stamina. Initially children in the foundation year level often have to be shown how to correctly hold a pair of scissors, and then how to manipulate their fingers and hands to make a cutting action. Scissor skill development “takes time and practice to learn how to cut with scissors. To be able to use scissors, small muscles and movements in the hand need to strengthen and develop” (Child and Youth Services, N.D., p. 1).

Rob Ives suggests different sizes of scissors for detailed work and also suggests using scissors for scoring card; “A small pair, with short blades for doing intricate work and a pair with longer blades for scoring and for cutting out straight lines” (Ives, 2018). Scoring is creasing along a designated path in preparation for accurate folding. Scissors with a sharp blade combined with children without enough control and practice at various materials (as demonstrated in *Figure 82*) are more likely to cut the card than score. Other tools for scoring include bodkins, metal BBQ skewers, blunt nails, butter knives and rotary trimmers with a scoring blade fitted.

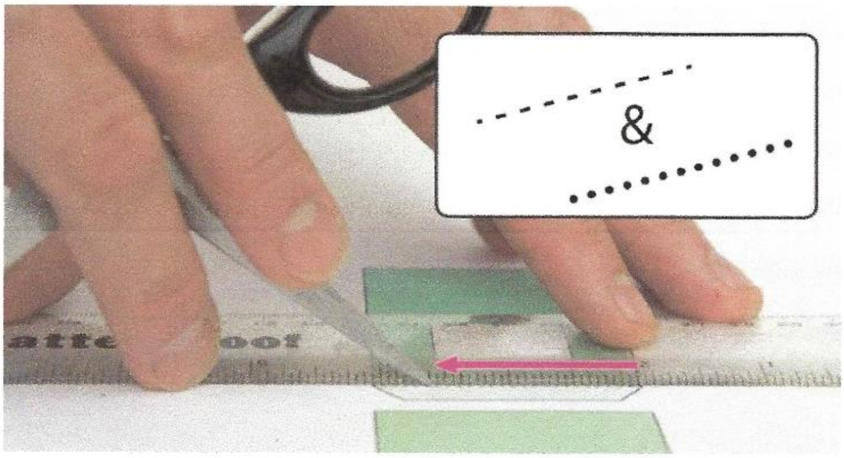

Figure 82. Using scissors to score lines.
(Ives, 2018a)

Over seventy two percent of teachers indicated that they use safety scissors with children in either an ad-hoc manner or developmentally during the class activities during the school year. Seventy five percent of teachers indicating that they teach in the prep area of the school stated they use safety scissors. However, only a third of these teachers indicated that they actually develop the skills of cutting. Practice activities may include using single hole punch that assists in the development of muscle strength.

At the other end of the primary school years in year six, sixty seven percent of teachers indicate that they use safety scissors, and of these only twenty two percent of teachers indicate that they teach skills in any developmental way. The fact that teachers indicate that they developmentally instruct children in the use of scissors across the primary years suggests stages of development. “They don’t have that developmental sequence of using a tool start out with scissors cutting playdough before you cut the paper before you cut the cardboard” (Interview p. 27)

The first is to explain how to select and handle scissors to complete a task including left handed scissors, spring-loaded scissors, and accuracy in moving from snipping to cutting. “The whole thing of scissors and how you hold them” (Interview p. 20) According to Sarafan in the popular on-line making site ‘Instructables’, “You should already have one of these lying about, and learned how to use them if you ever attended Kindergarten” (Sarafan, 2016, p. 17). This view fails to identify the complexities of using scissors correctly and with greater control, which is gained with practice and the need for these skills in transverse skills.

Secondly to more efficient ways to complete a task such as using re-entry into acute cuts and turning the object for curve cutting. “With scissors I we were cutting circles the other day and I have taught the how when we cut a circle with snips so there should not be any straight sides, so you turn the card” (Interview p. 107).

The third stage is looking at using specific scissors types to complete a task such as fancy cut scissors, surgical scissors and pinking shears. Less than two percent of teachers indicate that they use surgical scissors, thirty seven percent of teachers indicate that they use fancy cut scissors, and eight percent indicate that they use pinking shears. But the data does not support that these are introduced in a progressive manner across the primary school. Surgical scissors are only mentioned as being used in year one and year six by less than one percent of teachers in each of those year levels. Pinking shears are used by fifteen percent of prep teachers, zero percent of year two teachers, less than five percent of year four teachers, and less than ten percent of year six teachers.

9.6 The use of Stanley knives

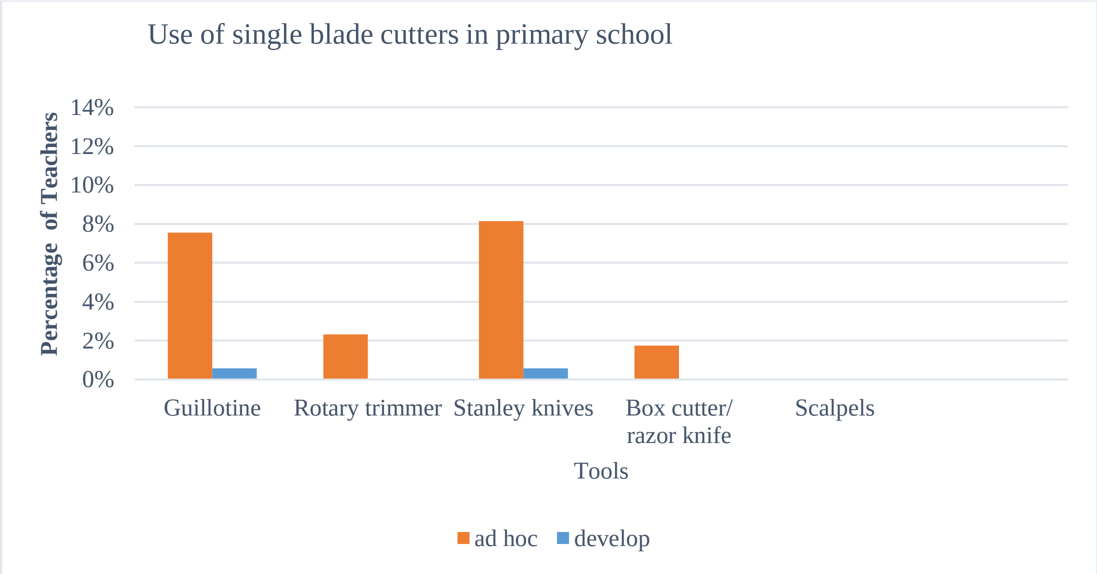

Figure 83. Use of single blade cutters in primary school.

Stanley knives were the most used single blade cutter used across the primary school with eight percent of teachers indicating that they use it with children in their classroom, as shown in *Figure 83.*

Less than one percent of all teachers indicate that they actually provide developmental instruction in the use of the tool and none of the developmental instruction occurred in the curriculum areas of maths, science, technology or art. Stanley knives were used almost exclusively within the survey area of ‘other’, not in mathematics, science, or technology, however two respondents (one in year two and the other in year five) indicated that they had used Stanley knives in art.

Table 13

Stanley knife use by all teachers

Teachers teaching using Stanley knives																																	
ow	ype	ize	Year level								ender	Csize	teach	Stanley knives Ad hoc										Stanley knives Developmental									
	catholic (1)	<60=0<200	p	1	2	3	4	5	6	p6	m (1) / f(0)	<12=1, 13-	<5 (1)	Ad hoc	Term 1	Term 2	Term 3	Term 4	Maths	Arts	Science	Technology	Other	Developme	Term 1	Term 2	Term 3	Term 4	Maths	Arts	Science	Technology	Other
0																																	
1																																	
2																																	
2																																	
4																																	
1														4	1	0		1															

Table 13 shows that only one teacher indicates that they provide developmental instruction to children (row nine). Here the teacher indicates that the curriculum area used with the Stanley knife is “other” and not maths, arts, science, nor technology.

The fourteen teachers indicating the use of Stanley knives in an ad hoc manner are less than ten percent of all teachers. It should be noted that in the ad hoc use of Stanley knives shown in the table it is not associated with the curriculum areas of maths or science. Stanley knives used in an ad hoc manner are however, associated with art (two Responses) and technology (one Response). No prep teachers use Stanley knives with their students. One teacher in year one, two in each year level from year two to year five and three in year six.

All teachers using the Stanley knives indicate that they have had more than ten years’ experience in teaching. Fourteen percent of teachers using the Stanley knives indicated that they were male with one of those teachers being the only teacher to indicate the developmental use of the knives.

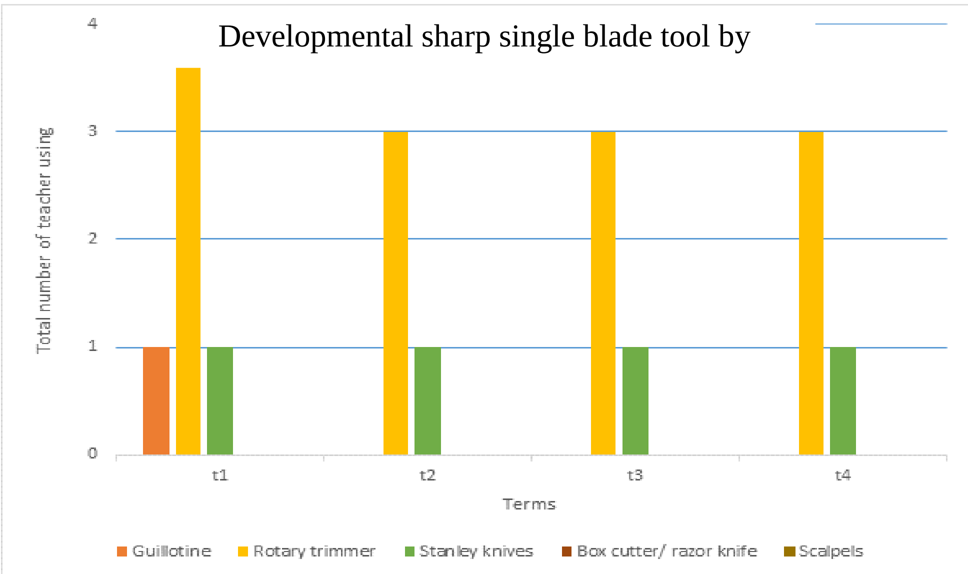

Figure 84. Teachers indicating instruction in the use of sharps.

Figure 84 shows a comparison of single blade sharp tools instructed in by teachers by tool type and term. It shows no significant difference; except for using the rotary trimmer and guillotine in term one. It should be noted that the numbers of teachers indicating use are small.

9.7 Wood

Chapter nine was to focus on specific examples from the data that had significance across the areas of tools, materials and adhesive methods. Within materials, the use of balsa wood was mentioned in several articles especially with the middle and upper primary school years. It was one that was anticipated to show a growth across the primary school as the increased strength and competence in use of tools to allow for more solid objects to be cut. Also, from this researcher’s experience, sometimes teachers use hacksaws (metal cutting saw) with wood and younger children rather than cutting metal because of their finer teeth and the less strength needed to cut wood such as balsa. However, balsa sheet only had two responses out of 172. So, it was decided to include a range of wood products as shown in Figure 85.

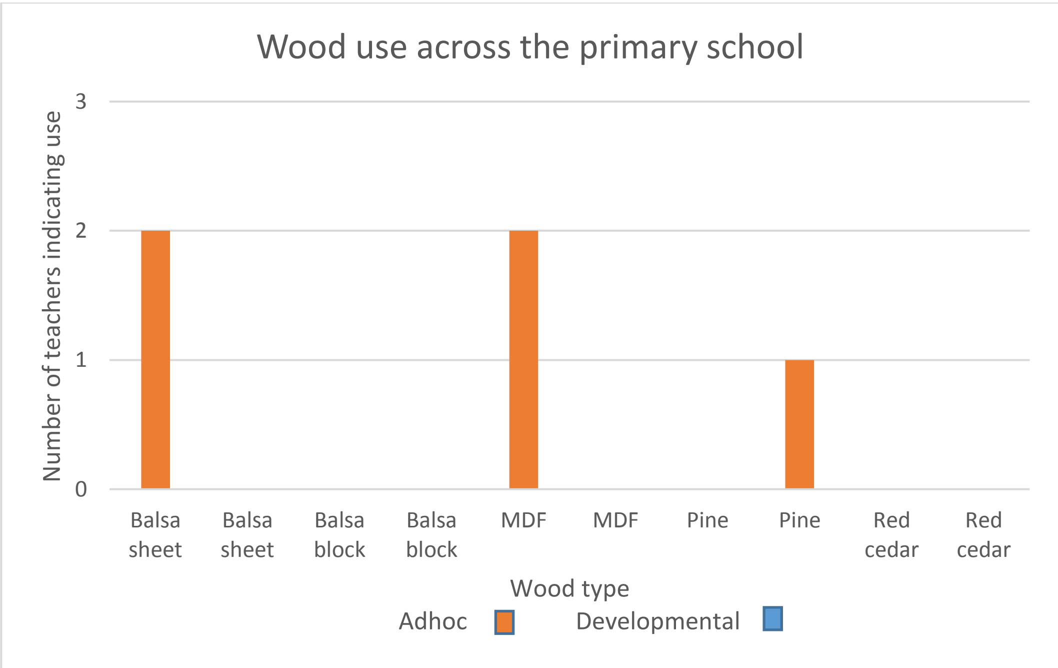

Figure 85. Wood use across the primary school.

There was no developmental instruction in the use of wood. Balsa sheet and MDF (medium density fibreboard) had two teachers indicating the ad hoc use of these woods with one teacher indicating the use of pine in an ad hoc manner. This reflects the lack of use of traditional adhesive methods for wood such as nails and screws, and the use of tools such as saws and drills.

From The list of saws in this study are those that this researcher has used in primary schools throughout his career. The saws are often associated with carpentry as is the hammer.

Table 9 there was no teacher indicating the use of fret saws or tenon saws in either an ad hoc nor developmental manner. One percent of teachers indicated that they used hack saws in a developmental manner and two percent with ad hoc opportunities. Nine percent of teachers indicated that they used a hammer with children in both an ad hoc and developmental manner.

From Figure 61 no teachers indicated that they used nails nor screws in a developmental manner, and less than five percent of teachers indicated that they used nails in an ad hoc manner. Less than one percent of teachers indicated that they used screws in an ad hoc manner.

The lack of usage of tools to cut, trim and shape wood and the lack of use of nails and screws meant that wood was not used effectively in the primary school.

9.8 Chapter summary

The use of tools and materials in the primary school have been reduced to those tools that either teachers feel comfortable with and used as they are needed to implement English and numeracy requirements. Scissor use is expected and continued development of skills in more complex use of scissors to cut curves for example are not taught. Tools materials and adhesive with no obvious requirement for awareness of risk such as glue sticks and paddle pop sticks are then used to assess safety. At the same time the children have been deprived of opportunities to develop their gross motor and fine motor strength and skills required in the primary school setting under the scaffolded support of the teacher.

Chapter ten, the following chapter, brings the previous chapters together in the discussion. It offers up some conclusions before offering recommendations in chapter eleven.

10 Discussion and Conclusions

10.1 Introduction

In this chapter, Chapter ten, the discussion will attempt to link the data obtained, curriculum and literature. The chapter will consider links to tools, materials and adhesive methods highlighted in the survey and then through the themes highlighted by the teachers of safety, budget, storage and space, and time.

"There is a growing concern that education systems are focusing too much on the accumulation of academic 'cognitive' skills at the expense of the more elusive and hard-to-measure 'non-academic' skills and competencies" (UNESCO, 2016a, p. 1). The development of fine motor and manipulative skills specifically in the use of tools, materials and adhesive methods in in primary school is an example of where Queensland students are not developing to their fullest capability. However, the narrowing focus on what skills are needed by children for the future has highlighted a lack of understanding of the interconnectedness of various aspects of developing the whole child, leading some administrators to believe that schools should only focus on 'literacy' specifically those involved with English and reading.

The Warwick report highlighted the dangers of narrowing education and the cultural and community aspects of learning, noting that

> Policymakers are obsessed with a siloed subject-based curriculum and early specialisation in Arts or Science disciplines that ignores and obscures discussion around the future need for all children to enjoy an education that encourages creativity, making and enterprise across the curriculum. (Neelands et al., 2015, p. 45)

Gonski (2018) predicted that human employment of the future will need higher order "skills that are not easily replicated by machines, such as problem-solving, interactive and social skills, and critical and creative thinking" (p. ix). Here the indication is that manual tasks and by association the use of tools, materials and adhesive methods are not as important for future jobs but there is no mention of the importance of fine motor skills in developing cognitive learning in children nor in the physical growth and well-being of the growing child.

An analysis of the data from the surveys indicated that the reasons for not engaging with the use of tools and in manipulating materials are many with several themes emerging including access and teacher upskilling in tools and materials, safety, budget concerns, storage and space, and time. Subsequent analysis of teacher comments in the interviews suggested that, where previously, professional primary school teachers were able to modify the implementation of the curriculum by acknowledging local resources, customs and children's interests they are directed to all teach the same content as laid out in the C2C. Teachers have indicated in the interviews that they would like to engage in integrated units away from silo teaching,

> I would love to go back to the integrated units so then you could do a whole craft under the sea and your craft could be under the sea and the digital technologies could be under the sea like I would love to go back to that and I would like to see more everyone have a computer and you know let's take a photo of our artwork and do this and upload and then make it into a cushion or something that you can carry it over a year project. (Interview p. 49)

That teachers in primary schools have a critical input into developing children's deeper understanding, curiosity and interest through integrated curriculum was reinforced in the revitalisation of the STEM agenda. Curriculum required a "renewed focus on achievement in the STEM 'building blocks', especially mathematics, as well as effective cross-disciplinary curriculum and pedagogical approaches that build student interest and performance in STEM education" (Education Council, 2015, p. 5).

This study investigated the use of tools materials and adhesives used in the primary school because of the concern of the knowledge and skill of children's motor and manipulative development do not match expectations of use from the various subjects of the Australian Curriculum nor the early years curriculum, especially those linked to the discipline areas of science, technologies, mathematics and art. There were mitigating circumstances identified within the surveys and interviews conducted within the study including resources, safety, budget, storage, curriculum and time.

Chapters four through nine provided an analysis of the research data from both of this studies survey and interviews. The findings were analysed under the headings identified within the survey as demographical information, tools, materials, adhesive methods, and safety and training. In this chapter the findings are discussed under the headings of tools, materials and adhesive methods, and then under the themes that developed out of the analysis of the data.

10.2 Tools, Materials and Adhesives

Access to a variety of tools, materials and adhesive resources for children in the primary school was poor, with no school programmes specifically identifying when and where to introduce specific tools or materials. Manipulative skills in the use of tools are identified as important as “tools change the properties or affordances of the limbs” (Kahrs & Lockman, 2014, p. 88). In their prep to year six C2C PowerPoint “Shaping materials” the Queensland Department of Education (Department of Education and Training, 2015b) use ‘verbs’ to discuss what the affordances the tools may allow citing saw, drill, punch, sand, twist, file, hammer, snip and carve. They highlight these action verbs often with pictures of tools of the same name, though they do not name the tools. Schools, Queensland Department of Education and Training, nor the Australian Curriculum provide a sequential list of developmentally appropriate tools. A fuller compilation across Australian Curriculum areas engaging in the use of tools in the STEAM areas is provided in Table 18. It should be noted that the merged year levels of prep to year two in the subjects of technologies curriculum and the arts curriculum align with the Australian band of these subjects , and that science and mathematics are by separate year levels. Further, the codes within the table are from the Australian Curriculum for example ‘acavam106’ refers to the ‘Australian Curriculum arts visual arts materials 106’

10.2.1 Tools

There was an expectation that children when they are in school would have learnt to use and practice with basic tools and materials as it is mentioned in the various early year's curriculum guides and the health department's early detection guidelines. For example, in discussing the development of fine motor skills Queensland early years framework highlights 'development' by "using and extending fine-motor skills when integrating movements and manipulating equipment, tools and objects" (Queensland Studies Authority, 2006, p. 26). The focus was on children being introduced to tools and materials such as scissors, staplers, and glue sticks as they continue to grow both mentally and physically. The Queensland early years curriculum guidelines identify the development of children at various stages using terms such as 'needing explicit support', 'with support', and 'with prompts' (Queensland Studies Authority, QSA 2006a) and further highlights what each of these may be in its assessment rubric on developing fine motor skills. Here it is important to note that the tools are introduced first with some experimenting by the child, followed by explaining as to possible further uses to the child as in the exploring column. The children are encouraged to make connections and choose what tools they will use for a task with support from the teacher. This is similar to other countries where "The children are guided in the safe and appropriate use of various machines and the basic tools needed in crafts" (Finnish Government, 2004, p. 234). Furthermore, in the comparison of tools used in the classroom in Germany, "it is stipulated that tools and technical devices should be used in class" (Rasinen et al., 2009, p. 7). The data in this study does not support that tools and materials are introduced in a broad and developmental way.

The Australian government identifies the importance of early childhood (Council of Australian Governments, 2009) and builds upon the states documentation of early years in the framing of the curriculum. Most notably that children should be provided with opportunities to use the tools and materials to develop their movement and coordination skills at their level as stated in Table 14.

Table 14

Fine motor Skills Development

Becoming aware	Exploring	Making connections	Applying
With explicit support, the child experiments with equipment, materials, tools and objects in the learning environment	With support, the child explores new ways to use equipment, materials, tools and objects for personal purposes	With prompts, the child uses manipulative skills appropriate to the selected equipment, materials, tools and objects to achieve a task.	The child combines and coordinates movements with developing control, strength and increasing confidence when manipulating equipment, materials, tools and objects.

(Queensland Studies Authority, 2006, p. 91)

This development continues right through primary school so that by age eleven and twelve (end of primary school) children engage with more demanding tools and materials. Yet, there is no explanation of what tools, materials and adhesive methods are appropriate. The data has shown that teachers are not using a variety of tools and materials as a learning tool for confidence or self-esteem of the child, nor in the development of fine motor skills. The links to the STEAM curriculum documents have not been implemented as expected as shown in Table 14, Table 15, and Table 16. The children develop confidence in handling a variety of tools and materials and "craft activities concentrate on continued refinement of fine motor abilities, through a variety of activities e.g. model - building, playing an instrument, drawing, wood working, cooking, sewing etc" (Western Australian Government, 2013b, p. 3). However the identification of suitable tools and materials identified within the curriculum and policy documents, including early years frameworks and C2C, is only done by analysing the images presented with the text and the teacher's own knowledge and skills, because the policy documents are not specific as what might be appropriate tools to use, such as in the technologies curriculum The design technologies subject of the Australian Curriculum: Technologies explicitly mentions that tools be used, as stated in Table 15, but does not name those tools. Further there is an expectation that students will 'explore' materials suggesting a variety of materials will be explored and that it will be done over time.

Table 15

Fine motor in the Australian Curriculum: Technologies

Design and technologies	Prep to year two	Year three and four
Materials and technologies specialisation	Explore the characteristics and properties of materials and components that are used to produce designed solutions (ACTDEK004)	Explore the characteristics and properties of materials and components that are used to produce designed solutions (ACTDEK004)

(Australian Curriculum Assessment and Reporting Authority, 2018d)

The Australian arts syllabus identifies that materials need to be used and manipulated "Through Visual Arts, students develop critical and creative thinking and proficiency in selecting, manipulating and adapting materials and techniques to support their conceptual and perceptual understandings" (Australian Curriculum Assessment and Reporting Authority, 2014a), where there is an implicit understanding that appropriate tools will be utilised. These banded subjects are grouped across several year levels, and are unlike 'core' subjects like English, mathematics and science which are provided with year by year content documents.

In mathematics for example specific fractions to be considered for each year level as in Table 16 are mentioned (Australian Curriculum Assessment and Reporting Authority, 2018a).

Table 16

Mathematics sequence of content

Mathematics	Year 1	Year 2	Year 3
Fractions and Decimals	Recognise and describe one-half as one of two equal parts of a whole. (ACMNA016)	Recognise and interpret common uses of halves, quarters and eighths of shapes and collections (ACMNA033)	Model and represent unit fractions including 1/2, 1/4, 1/3, 1/5 and their multiples to a complete whole (ACMNA058

The English sequence of content in the Australian Curriculum also specifies specific content, such as that found in punctuation. Table 17 shows a progression of these examples in year one, two and six from the English scope and sequence of the Australian Curriculum.(Australian Curriculum Assessment and Reporting Authority, 2018c).

Table 17

English syllabus samples

English	Year 1	Year 2	Year 6
Punctuation	Recognise that different types of punctuation, including full stops, question marks and exclamation marks, (ACELA1449)	Recognise that capital letters signal proper nouns and commas are used to separate items in lists (ACELA1465)	commas to separate clauses (ACELA1521)

Opportunities to engage with tools, materials and adhesive methods through the English discipline area abound in the activities related to include using scissors, glue, and the development of handwriting skills. The Queensland C2C English units further add specificity, as in the middle years primary school by stating the titles of the humorous books to be used such as, ‘The Twits’ and ‘Georges Marvellous Medicine’ by Roald Dahl, and ‘Rowan of Rin’ by Emily Rhoda. Each State school using the C2C units is following these texts. The reasoning behind this is the perceived educational disadvantage as students move around the State as well as being linked to the comparative nature of assessment when considering moderation and the achievement levels of children. There is not a mention of tool use other than handwriting and the use of pencils, and that is on the wane in primary schools, “personally, I think unless its illegible I think I wouldn’t mind if the kids print or did cursive as a long as its legible and then they all go onto computers anyway high schools you don’t hand in handwritten draft anymore,” (Interview P54). This is further elaborated in the following interview exchange;

> They don’t have to have a style yet because half of them don’t do cursive writing so once they develop the cursive writing then they would move onto doing their own style (Why don’t they do cursive writing?)

> Because they haven't, because they don't form letters correctly yet, I have kids in class that can barely write a sight word. (Interview p. 96)

When asked about puppetry as a way to integrate English oral language and engage children in their stories with the use of tools and materials; it was stated "No! all of the assessment in the C2C to do with English is to do with writing" (Interview p. 97). Further the teacher indicated that the C2C "is boring. The kids find it boring, the kids are not engaged" (Interview p. 97).

"The curriculum does the thinking …the curriculum is controlling the children's thinking and you know step by step the learning is regurgitated, and we are not giving them the freedom to explore tools use tools" (Interviews p. 13). "It is as if we expect children to (develop) these skills by osmosis, but we are not giving any time to teach them" (Interview p. 14). For some tools and materials children need to actually use them, discuss them and see them especially when engaging in ideation for problem solving. When asked how the children made holes in wheels for the axles the teachers actually drilled the holes. "Yes, we had to drill holes We did that for them before we bought them to school which is probably not good, but we already put holes into them before we bought them in" (Interview p. 33)

The difference in the Australian Curriculum English and mathematics as well as being considered priority disciplines, have a long association with primary schools with a history of teaching content in specified year levels. The technologies syllabus on the other hand, is rather a new comer and its focus on process rather than content may be a reason for not having specifically identified tools and materials appropriate to introducing at a certain year level. Seiter (2009) noted in Austria that "Crafts and Technology' does not have a strong image compared with other curriculum areas and suggest part of the reason is too few trained teachers. However, Australia has had a history of arts and crafts in the primary school that has diminished over the years, "we also don't give the time it takes, teachers are not allocating the time that the arts and creative subjects (need)" (Interview p. 76).

Teachers have been removed from effectively and safely introducing tools to children, to enable them to complete activities that require children to engage with tools, materials and adhesives to create, innovate on and make products.

10.2.2 Discussion on materials

The failure to encourage the range of tools in primary schools has an impact upon the range of materials that children engage with. Safety scissors that are blunt or only designed to cut paper are useless on fabrics, card and thin metal and plastics. Therefore, it was no surprise that the survey results indicated that these materials were poorly accessed by children in primary school. Plastic ties are also used to tie cardboard constructions together from prep year onwards and therefore was expected to show a higher response across the whole of the primary school. As Figure 63 showed this did not occur, string was the most common tie.

The subject discipline approach to using materials has meant that children are not accessing cheap, novel, contemporary resources because teachers are not identifying their possible use in primary school activities in earlier year levels. Simple electrical circuits are now found in the Australian Curriculum science at the end of primary school, whilst the students are encouraged to design moving toys in technology in the middle primary year levels. The construction of toys needs the putting together of different materials using adhesive methods of some sort including adhesive tapes.

Cellotape or sticky tape, masking tape, electrical tape and paper tape are found in most primary schools. Tape is a common resource used in the primary classroom as a quick and easy adhesive method for construction and collage activities. Its absence from the adhesive methods page of the survey was noted by a comment in the survey. As a section, it was inadvertently left off the final draft of the survey form.

10.2.3 Discussion on adhesive methods

The use of adhesive in the primary school is primarily used to attach sheets to work books without any mess. When queried in the interviews regarding the populatity of glue sticks the responses were ‘cheap’ and “less mess” (Interview p.17) and “non-toxic, I don’t think we use it properly though and I think it is a taught skill.” (Interview p. 43) “Because that is the quickest and easiest way to get work sheets and things glued into books” (Interview p. 58).

Other non-messy and cheap adhesives were staplers and paper clips. Interestingly staple guns can be used as a type of plier stapler where the action is to grip and squeeze the handle is demonstrated in the Queensland C2C Prep to year 2 professional development PowerPoint (Department of Education and Training, 2015a)

The use of other adhesive methods such as solder, hot glue, nuts and bolts were not used as the materials and tools associated with such adhesive methods also were not used. The Queensland support materials for schools C2C has a professional development support document that suggests ways to join materials including split pins, glue, nail, weave, thread, tie, screw, bolt, zip tie, sew, and staple (Department of Education and Training, 2015a). The possibility of children being hurt by hot or impact tools raises the issue of safety. Also, some children are allergic to adhesives and their safety needs to be considered.

10.3 Safety

Safety had several aspects identified by the participants including behaviour and maturity of children. Teachers indicated that the reason children are not given access to wood such as medium density fibre board and pine is that “people would assume you would have to have nails or screws or something like that and there in comes the risk factor having issues with children having hammers or screws and screwdrivers” (Interview p. 58).

Teachers indicated that supervision when using tools requires small groups of children, “you would need one adult for every four or five children some even less than others …[so I] Don’t use Stanley knives” (Interview p. 1). Some gross motor activities with mandatory workplace requirements state specific supervisory numbers where significant chance of death may occur such as in canoeing. We don’t do some tools, “Because we don’t have the right ratio of students to teachers” (Interview p. 77). Other teachers have indicated that “in the past there have been safety issues and we have had to supervise the children closely, I’ve got a few Stanley knives, but I would never just give them to children to use unless they were in a small group and they had an adult ratio supervising them” (Interview p. 32). Lancy (2016) suggested that children learn through “use of objects like knives; self-injury should be a learning opportunity” (p. 19)

> Yeah I probably like the manpower in here, I wouldn’t do it with a class of twenty two and that’s a small class but if I had parents that’s when

> I'll do sewing, I'll have a parent for small little groups just to help with I don't know, with your needles and stuff like that I'm someone that would definitely give everything a go though I know people don't, they don't even teach art because they don't like the art kind of thing, give it a go it will be some child's passion that we haven't fulfilled. (Interview P 50)

The behaviour of children is a growing safety, and commercially available behaviour programmes and specifically allocated weekly behaviour lessons not involving tools, materials and adhesives are being implemented. These introduced lessons takeaway time from curriculum and reducing opportunities to engage students with tools. "Trying to make sure everyone is being safe, and you have big behaviour issues in your class like with the use of the hot glue gun" (Interview p. 57). In 'playing with knives,' Lancy (2016) suggested "of course some precautions may be taken to prevent injury to clumsy toddlers" (p. 5).

The safety issues with regard to the maturity of the children is related to two factors. The age of the child and the experiences of the child. "The age of the children-too young, tools need to be developmentally appropriate" (Response 29). The age of the child has a lot to do with the strength of a child hence a young child is unlikely to wield a heavy rubber or wooden mallet with any sort of control. The experiences of the child relate initially to having opportunities to develop fine motor skills using a variety of tools on differing materials and being able to identify what tools work better with some materials and consider the possibilities of tools. The latter may be by considering tools that they have being used by others or pondering what uses of a tool may be from seeing them. Lancy (2016) provided various anecdotes on children using various sharp and pointed tools including knives and arrows, hoes and sickles with minimal injuries. Further he indicated that the children learn by imitating adults using functional tools. "I haven't specifically taught any, I don't think, we have used, I have used myself Stanley knives that I haven't allowed the kids to use the Stanley knives it's been just basic scissors, rulers" (Interview p. 77). Choosing real tools that are suited to the physical capabilities of the child are preferable to those tools that do not do the job but are deemed safe, examples of this may be the use of a pin hammer and a fret, coping or small metal saw for the younger child.

School workplace health and safety requirements and recording are becoming ponderous for teachers as well with requirements to have policies in place for all contingencies. Some teachers in the survey indicated a misconception in what risk assessment means in that they wanted to use tools and materials that did not need risk assessments, “things that are easy, don't require risk assessments, and are readily available” (Response 91). However, “as a teacher it is your responsibility to make a risk assessment of the materials, tools and equipment that you intend to use and to put appropriate strategies into place to avoid injuries to your students and others who will be using them” (Albion, 2018, p. 213).

These requirements should not be ponderous or too onerous though current legal documentation required is becoming onerous, “professional responsibility should include weighing up not simply the risks involved in undertaking particular activities, but also the risk to children's learning and development if we do not help them to learn to manage potential dangers” (Pound, 2011, p. 3). This sentiment is further iterated in the Fundamental Movement Skills statement, “It is important that you discriminate between risk management and activity avoidance” (Department of Education Western Australia, 2013b, p. 34). However, “I think I said health and safety like having to do all that paper work for a really low risk task, like hello, I can manage with risk without doing that with time and money actually having the tools and maintaining them after you go back a year later are they still there and are they still workable” (Interview p. 28).

The use of some materials and adhesives also raised the concern of the safety of children with allergies, adhesives were a specific mention. The safe use of adhesives is indicated within the Australian Curriculum with examples using glue sticks and hot glue in the Technologies syllabus, design technologies for the band foundation to year two. Here the child is expected to use the glue stick safely but the document does not specify what this means.

The safe use of glue sticks is demonstrated in the work samples section of foundation to year two band of the design technologies subject of the Australian Curriculum (Australian Curriculum Assessment and Reporting Authority, 2018f) The ‘safe use of glue sticks’ as is demonstrated in the Australian Curriculum generates confusion over what safety actually means. In the video snippet of the student demonstrating the high standard, the annotation states that the child “Demonstrates gluing paper to paper safely using a glue stick" (Australian Curriculum Assessment and Reporting Authority, 2018f). However, the student allows the paper to ride up when applying to one piece and does not apply the glue evenly across the whole article to be attached, as shown on the video at the seventeen second mark. Further, the student uses the glue stick adhesive to apply painted collage objects to acrylic painted surfaces, not directly paper to paper, which effectively would not adhere for any length of time. Time is not allocated to teach children to effectively use glue, "I think it is a taught skill because even now they don't just do the edges and the middle it's like a whole glue stick on a page but it's easy and non-toxic" (Interview p. 45). Here the student is not eating the glue, as mentioned previously, but the effective application of the glue is not apparent and the riding up of the paper would not suggest that it is a safe application to the materials. Later in the same video blog the student is seen applying extra glue stick adhesive under the corners of other pieces previously attached. This is ineffectiveness is reinforced by the teachers who state, "Because they are simple and easy to use, they are not necessarily effective" (Interview p. 78).

A final consideration to safety is the safety of property. Tools can be damaged as well as furniture. However,

> If the students were taught in the right way I don't think that it would be a huge issue they just need to be taught how to needs to be really explicit but in saying that it would also be very helpful if there were more bodies in the room like more adults in the room to assist to make sure when you are helping to make another student that the other one is not hurting someone else or hurting themselves by accident or probably the other part of it would be the furniture. (Interview p. 70)

Being alert to potential dangers presupposes that teachers have had some training in the use of tools materials and adhesives but the was not the case highlighted within the survey. Many teachers when discussing why they use or don't use tools, beyond work place health and safety requirements, refer to personal experience, both, of the child and the teacher. Some upper year teachers have indicated that they do not get children to use scissors to trim activity pages to fit in their exercise books, as it is messy and time consuming, rather they are to fold, and then glue stick them in. The use of glue sticks to insert pages of activity into exercise and scrap books related to literacy or reading, including those that show pupils can close an activity on the correct use of nouns or phonics by gluing a matching picture to a word, has diminished the understanding of risk taking and learning by children.

Because they are unable to practice the correct and safe use of tools, children have been reduced to listing some suggestions for safe use of tools without actually engaging with the risks associated with tools. Electrical, sharp or pointed tools are actively discouraged. During design problem solving children are reduced to drawing a sketch and stating what they would do to solve a given problem without the time and practical opportunity to try their solution out. The supervision and lack of support to assist in the safety supervision of children, as in the assistance of parents and the supervision available by teacher aides has reduced over time and was raised in both the comment section of the survey and in the interviews. Part of the consequence of this is that teachers are no longer engaging children in tasks that require development of fine motor skills as in developing competence and dexterity in handling tools and materials such as single and double blade tools, nor screw drivers and wire cutters. This also means that children do not have opportunity to engage with newer materials and technologies such as 3D printers or to construct robotic or computer-controlled devices from scratch.

10.4 Budget

Prioritizing budgets is always an ongoing problem in any organization. Effective use of monies to purchase tools, materials and adhesives depends upon several factors. The first consideration is what tools and materials are going to be best used for the children to learn the curriculum. This has to do with access of the child and the ability of the item to do the task required. If the active participation of the child needs hands on materials and tools, then enough resources need to be purchased for each child to access. However, if the budget does not allow for that then alternatives must be devised; sharing between two or small groups or by purchasing cheaper versions of the tools. Even so, a cheap six mm paper hole punch costs about two dollars and for a class of twenty-five children this equates to fifty dollars. From the comments section of the survey money was a concern, “Two hundred dollars a year doesn’t go far when buying materials to use for all craft activities in the classroom” (Response 42). “Cheap, realistic tools such as paddle pop sticks to help with maths tasks such as grouping” (Response 92). The cheaper versions may not make budgetary sense in the longer term if they break or regularly fail to do the task required. Quality often costs more. But the individual curriculum school budgets often do not take into consideration of non-consumable items like tools. For example, “Well I know that the art bucket we were allocated $xx, which was covers cardboard paints and that works out less than a dollar a student per week” (Interview p. 76). Further,

> I guess access to money because at school we no longer have a class budget, the art budget is very small and I don’t think we have a technology budget so if I were to buy pieces of balsa or whatever it would have to come out of my own pocket and it is very difficult to get money out of families to pay for these things so it is usually the teachers [who pay out of their own pocket]. (Interview p. 102)

Budget also affects professional development opportunities for teachers. Priority areas for professional development are not what the teacher may ask for rather at the whim of the system or the principal. For example, principals have stated they will not support teachers doing professional development on the weekend in science because that is not a priority. And yet Queensland Chief Scientist, Dr Geoff Garratt is cited as saying “Professional development for teachers and educators is essential” (Department of Education Training and Employment, 2016c, p. 2). Hunter (2017) stated that “hands on materials for STEM often cost money” (p. 3), and “STEM is a national priority” (Australian Curriculum Assessment and Reporting Authority, 2016). The directive from the education systems at the regional level, is that professional development must be linked to the strategic initiatives. and link specifically as reading and comprehension, behaviour management and improving reading data. Interestingly, anecdotally, there is no mention of STEM nor STEAM in some school strategic plans as stated by some participants in science and mathematics workshops.

10.5 Storage and space

Storage and space are multifaceted aspects of using tools materials and adhesives as well. The storage of tools materials and adhesives need to be considered in both the access and safety of the children and the items themselves. Workplace requirements in some schools now require tools and adhesives such as safety scissors and glue to be locked away when not in use. This does not mean having them on display in the classroom, and in fact all scissors and knives must be stored in a locked cabinet away from sight. This may be safe but does not mean easy access by the teacher, nor does it support the need for children to see the tools as scaffolding for considering which tool to safely choose. The local university is considering having lockable see through cabinets in its makerspace to try and accommodate the need for tools such as scissors to be locked away and yet to be visible when trying to consider alternative tools for problem solving. Storage of tools is also problematic when it comes to replacing broken and missing parts and maintaining tools when used by multiple classes and teachers. The storage of tools and equipment must be able to be easily accessed by the teacher so as not to waste time "It is important to have a convenient way of storing equipment so that time is not wasted taking it out and putting it away" (Physical Education Branch, 1970, p. 9).

Storage of materials is necessary for forward planning of activities that require resources from a variety of locations to be collected by the teacher in preparation for a task. In the development of skills, it is often a requirement that a child perseveres with a task longer than the class session or day. This means that the project in development needs space and storage which rarely exists. "We haven't got enough space in this size classroom" (Interview p. 19). When asked how children stored the products they were engaging in over days or even weeks, "Well that was difficult because they had things all over the room – the room was in a bit of a mess for a few weeks because then and it was time for all the left-over things to go home we didn't have space to store it and that's another issue as well in a school" (Interview p. 34). Space was also highlighted more than ten times in the survey comments section including "space set aside to collate and store materials" (Response 94).

"We just use up the classroom space, …if the task went over the three or four weeks and then they usually go home if a child hasn't done it in that time most of the time they don't get to finish it" (Interview p. 29). Addison, Burgess, Steers, and Trowell (2010) state "another important feature of the visual environment to stimulate pupil's creativity is displays of work in progress" (p87). The classroom space goes beyond just the physical space and must allow for the children to access a range of tools and materials to be able to function at an increasingly creative and innovative space. Opportunities to engage in positive interactions, to collaborate, communicate whilst exploring tools, materials and adhesive methods whilst working with resources that "should be accessible and suitable for the emerging interests of the child and be open-ended for multiple possible use" (Whitebread, Kuvalja, & O'Connor, 2015, p. 27).

Time is also an aspect in using adhesive methods that require curing time. Children develop patience and resilience when using adhesives such as PVA glue that require time to set and hold in place and twenty-four hours to cure.

10.6 Time

Time was a major but complex issue that raised several underlying difficulties in the primary school curriculum in today's schools, most notably the impact of narrowing the curriculum and associated standardized testing regimes. Queensland curriculum and assessment authority suggested times for English were for prep to year two, six and a half hours per week, years three and four, five and a half hours, and years five and six, four hours per week. The data from the study indicated that schools were spending up to fifteen hours of school time a week teaching English. However, "The hours do not assume how schools should organise learning and are not required hours. The number of hours is based on the indicative times used by the curriculum writers" (Queensland Studies Authority, 2011). There is an expectation that the recommended hours allow for the education entitlement for children includes all "the learning areas described in the Melbourne Declaration on Educational Goals for Young Australians" (Queensland Studies Authority, 2011).

Allocating priority to some curriculum so that some areas are more important than others, as identified by assessment regimes, allows for a narrowing focus on curriculum. There are two issues with narrowing the curriculum and impact of data collection, testing including standardised testing in Queensland schools. The first is that the testing is not wholistic in its assessment of a child's development and secondly it prioritises not the whole child's development but legitimises the selection from within the eight learning areas. As no standardised assessment is conducted in design technology or the arts, there is the temptation not to do those subjects. When a school's administration was asked what the teachers in the classroom were to do in the (Australian) technologies curriculum the reply was, "oh don't worry about it focus on the literacy, English literacy" (Interview P15). Many teachers in the classroom are aware of the reduction in time allocated to all the curriculum areas but are frustrated,

> I believe it is important for school leaders to ensure that classroom teachers are allocating adequate time to all curriculum areas, so that students have consistent and regular exposure to all curriculum areas. At present it seems the focus is only on literacy and numeracy at the expense of curriculum areas that nurture creativity and abstract thinking. (Interview p. 110).

The reduction in time for other curriculum areas such as arts and technology have an impact on creativity and self-esteem. Creativity and thinking were the focus of a study by Craft et al. (2014) that suggested it "was enabled by affording time and space and teachers standing back" (p. 18). Cryer (1996) suggested that "it takes a lot of practice before a child learns to control his hands and focus his ideas well enough to draw things we can all see" (p. 209).

The early primary years commercial programmes in literacy, phonics, spelling and reading are taking up to two hours a day, on top of the school English programme such as C2C which is about one hour per day, making a total of three hours per day or fifteen hours per week.

> We are doing the (commercial literacy programmes) two hours per day, we're supposed to be doing it as much as we can. Probably an hour a day on our English but we have adopted and adapted it as well as following the goals of the C2C, the goals and objectives of the curriculum stories and assessment, getting rid of all the fluff. (Interview p. 4)

Other teachers indicated that similar total amounts of time "English twelve to fifteen hours per week" (Interview P23), "About ten hours of English," (Interview p 26) "At least ten hours of English per week" (Interview p. 37), English "two hours per day." (Interview p. 67, p. 74), "Literacy and reading they would have done three hours" "It is difficult for the lower grades, I think they have a lot more literacy and numeracy time, for me it is about eight hours a week" (Interview p. 104). Other jurisdictions are also overloading the English literacy focus "California recommends two and a half hours of ELA (English Language Arts) instruction each day in grades one to three, and the district recommends three hours each day in Reading First

Schools” (McMurrer & Kober, 2007, p. 8). When asked why this effective doubling of English time, some teachers indicated it was “because I had to get my data up” (Interview p. 23). Another teacher indicated “everything is about data at the moment, so the pressure of curriculum is all about data and data then at the moment is to do with English and maths very much so and that’s a real priority” (Interview p. 78). Griggs (2009) also indicated concerns of reducing times on subjects “which have become increasingly marginalised within curriculum time, as a greater emphasis has been placed upon the teaching of core subjects such as English (Literacy), Mathematics (Numeracy) and Science for which annual results are published for all primary schools” (p. 122).

School and system efforts to improve literacy gains in standardised testing have led to seeking commercial support programmes to assist teachers. Many commercial programmes come with caveats to child improvement that state that the programme must be conducted daily, with minimum time amounts, and in small groups with a trained teacher. With multiple such programmes operating in schools increasing amounts of curriculum time are used for the core subject. Program efficacy is assessed using internal pre and post-test assessments to confirm growth to support data driven requirements of systems. An example of a commercial program is Levelled Literacy Intervention (LLI). “The *Fountas & Pinnell Levelled Literacy Intervention* is a powerful, short-term intervention, that provides daily, intensive, small-group instruction, which supplements classroom literacy teaching” ("Leveled Literacy Intervention (LLI)," 2018). One paper referred to research written by “three CREP researchers were responsible for ensuring that the districts understood and agreed to participate in the study while implementing LLI as intended by the developers” (Ransford-Kaldon et al., 2010, p. 7). Here the study observed that the programme was implemented as was stated and it is important to note that this supplements classroom teaching. This is often done by taking children out of class during school time but not while they are doing other English or literacy activities. What activities they are withdrawn from are not referred to in the assessment of the commercial program and the influence of other class teaching initiatives is unable to be cited.

NAPLAN (National Assessment Programme Literacy and Numeracy), as well as the education systems requirements for term (ten week) records in standardised benchmark reading assessments, and the focus of having no child having a ‘D’ or an ‘E’ (regional education directive to state primary schools) in their school report cards are all directing the priority of the school curriculum, not the learning of the child. The time for testing does not come out of the over-subscribed English literacy time allocation, “no, usually it is the creative subjects that suffer because the emphasis is on literacy, numeracy and science” (Interview p. 80). Also, another teacher when discussing the problem of interruptions such as sports days and swimming days, visiting art and science shows, indicated that any time lost from classroom activities is made up in literacy and numeracy, but not “the creative subjects lose hands down every single time” (Interview p. 60). “There’s huge pressure placed on I guess the year three and five teachers” (Interview p. 48), and asked if they would take more time from other subject areas the response was “You would have to work your English times better because you don’t have any time but yes if we did I guess it would be ICT and art and those subjects” (Interview p. 48). The Australian Curriculum supports these interruptions when it states that,

> The industry increasingly provides specialist services for schools, as appropriate, through experiences such as visiting performances, demonstrations and exhibitions, artists in residence, teacher professional development and access for students and teachers to specialised facilities in galleries, concert halls, theatres and other venues. (Australian Curriculum Assessment and Reporting Authority, 2018c, p. 9)

The Australian Curriculum does not elaborate on appropriate time allocations for these interruptions. Further, more remote schools would have to factor in travel time and transport costs.

The failure of the systems to identify that recommended minimum time allocations for Australian Curriculum subjects and the pressure to have subjects in priority silos has caused a decline in student’s capabilities in developing fine motor skills and the instruction in the use of tools and materials across the STEAM subjects. The introduction of a tool and safety discussions could take place under the auspices of the technology’s curriculum and the practice and development of strength and confidence could be utilised across all other curriculum areas.

> Scientists have revealed and made the connection between working with our hands and fingers and mathematical abilities. Our finger and hand movements occur in the same areas of the brain as math which explains why musicians and math proficiency are often correlated (very much a STEAM exercise). Toys that encourage fine motor skills have the added benefit of growing the brain, especially the parietal cortex. (The Toy Association STEM/STEAM Strategic Leadership Committee, 2018, p. 11)

Physical development of the child with regards to fine motor skills and manipulative control require regular and consistent practice of the muscle groups to gain control and expertise. However, the banding of curriculum areas into foundation to year two by the Australian Curriculum and by the Queensland Department of Education has meant that it is possible for schools to forgo the opportunities for the development of fine motor skills and related gross motor skills of children. The critical banding age level of foundation to year two in such areas as technologies and the arts has meant that students may miss out on their physical development opportunities in the use of tools and fine motor skills, as they could possibly be asked to complete the content requirements of the curriculum in the last semester. For example, the standard expected by the end of year two in technologies states,

> With guidance, students create designed solutions for each of the prescribed technologies contexts. They describe given needs or opportunities. Students create and evaluate their ideas and designed solutions based on personal preferences. They communicate design ideas for their designed products, services and environments using modelling and simple drawings. Following sequenced steps, students demonstrate safe use of tools and equipment when producing designed solutions.(Australian Curriculum Assessment and Reporting Authority, 2014f, p. sequence of achievement)

The student achievement standard in the Australian Technologies curriculum clearly states that the children will demonstrate safe use of the tools, indicating that they, the student has had instruction in the tool use and safety as well time to practice. However, timing of this is stated as “State and territory curriculum and school authorities are responsible for the implementation of the Australian Curriculum in their schools, in line with system and jurisdictional policies and requirements. They make decisions about the extent and timing" (Australian Curriculum Assessment and Reporting Authority, 2014b, overview).

> I just think people assume a lot of these skills are there so the task will be presented oh we are now doing this but there's been no lead up to check that they can actually do that there's just an assumption of skills that the children come with and it's not true even for average to above average children it's not just your lower achievers all students haven't got those skills that are presumed that they have its not quite true. (Interview p. 27)

The Queensland Studies Authority (2011) stated "The hours do not assume how schools should organise learning and are not required hours" (p. 2). The Department of Education, Training and Employment further added to the confusion in The Curriculum into the Classroom (C2C) newsletter number nineteen, when posing the question is it a requirement that schools teach each learning area/subject every year? The response was "No. The learning areas are to be provided in each year level or across the bands" (Department of Education Training and Employment, 2016a, p. 7).

These bandings provide opportunities for the content of the discipline areas to be collated by schools into what fits them best, for example theoretically the technologies syllabus requirements for band one could be done in semester two year two. However, it is a very naive view that the fine motor skill development and manipulation control of tools could be conducted in the same fast-tracked manner, and that the Australian Curriculum discusses skill development in that way. "It doesn't and if you didn't know that those prerequisite skills were, I, maybe I just do it but I don't think there is anywhere in our current curriculum that actually has those skills spelt out" (Interview p. 28).

The C2C newsletter for design and technologies, when talking about resourcing needs required to teach design and technologies, suggested that depending on the unit taken "students may need access to simple hand tools and materials" (Department of Education Training and Employment, 2016b), but does not elaborate on the physical gross motor or fine motor skills required nor provide a sample list of tools. Maintaining and purchasing of appropriate tools requires time by the teacher who is best suited to identify tools and materials to be used by the children in their class. Tools that are damaged or worn are dangerous and need to be maintained or replaced. Maintenance may include sharpening, oiling and cleaning in preparation for storage and use by the next class. This may be conducted by the class teacher or a designated aide or grounds person who have been given designated time to do this.

The collection of tools adhesives and materials to a central location may be conducted by children under supervision of the teacher ready for storage. The collection methods may include returning to a designated spot on a shadow board for hammers and screwdrivers or a box designed to collect the tools such as scissors. Children can be taught to identify broken or mis-fitting tools and to report these to the teacher for actioning. The clean-up time needs to be factored into the lesson and safe and efficient return of tools materials and adhesives makes for more time engaged with the task at hand.

Many tasks given to children now that utilise fine motor skills and the use of tools, materials and adhesives are those that can be completed within a single specific lesson time frame. Depending on the capabilities of the child the opportunity to reflect on their product is severely diminished.

> You don’t get time, there’s no time in this to do the reflection phase to how could I have done it better or what, look at that one you really did I like how you did that I’ve got a bit of time to go and change my own this is learning from each other I think that we don’t do that as well as we used to. (Interview p. 26)

Reflection time allows the student to receive praise for their work and suggestions on improvement including the objects attractiveness. In their three-level framework for curriculum analysis Rasinen et al (2009) suggested that aesthetical considerations are part of the top level, level three, which includes “technology, understanding, reasoning and application” (p. 371).

> I suppose you could see that in multiple ways in that the students currently couldn’t use most of those tools so their level of confidence with them would be quite low but if they were taught explicitly how to use them and given the opportunity to practice in a supportive environment then their level of confidence would obviously rise and could be for certain children that are very hands on would be beneficial. (Interview p. 64)

The construction of products using tools, materials and adhesives safely and appropriately over several lessons is critical for students to develop persistence, resilience and their confidence. Craft activities according to the Finnish curriculum documents suggest that children's " perseverance and problem solving skills are developed both in the group and independent work" (Finnish Government, 2004, p. 240).

> Persistence and resilience not so much they don't have because they don't have had that developmental sequence of using a tool start out with scissors cutting playdough before you cut the paper before you cut the cardboard if I then gave my children a pair of pattern scissors with cardboard to cut most would give up because we haven't got that skill yet a few would persist but not many. (Interview p. 27)

Preparing suitable materials and adhesives prior to a lesson and ensuring sufficient quantities requires time. Often this time was allocated to the teaching assistant, but with insistence that teacher aides only work with children directly and only in literacy and numeracy lessons requires the teacher to prepare all the materials,

> Because you've got to take your lunch break to get it all set up or it comes into your thinking like I can't do it in the middle session in the second half because I've got no time to prepare for it so I can't go straight from a maths lesson to that because I need to put things out for the kids I need to have it all set up ready to go and if were painting on top of the boats or whatever it is I need to have that ready to go but I can't get it ready an hour before so I suppose that all comes into the preparation. (Interview p. 57)

Time and support at the completion of an activity are also required in the clean-up and storage of tools, materials and adhesives, both in the training of children to assist in cleaning up their mess and the actual clean-up. Clean up time was indicated as an inhibitor in doing messy tasks in chapter four. Teachers indicate they do use "PVA but it is messy and again we don't have the teacher aid time, it's all teachers, I have to clean up the mess with kids and often the kids make a greater mess when they are cleaning up" (Interview p. 78).

The curriculum issues raised with increasing assessment and reporting requirements had two further influences on the time teachers had to improve their teaching. That of reflection by teacher to record observations to improve child learning, and reflection by staff to improve school wide learning as well as seeking professional development opportunities. Regularly teachers are having afternoon meetings four days a week including administrative staff meetings, school area meetings, curriculum meetings and required system and regional training sessions such as reporting, child safety, anaphylactic shock, school events, and wellbeing.

> Needed to make it go faster but a constant rat running around completing something pausing, how could I have done that better what could I have done different that reflection has disappeared whereas I think we used to do that quite well, …. to be creative as well to come back and go oh my product didn't work you know my prototype we never get past the prototype. (Interview p. 27)

Snowman (2009) provided back ground information to the importance of research into children using equipment such as tools and reflects upon children's development from researchers such as Vygotsky and Piaget. Elaborating on Erikson's theory of psycho-social development and children in the primary school age range (six to eleven years old) identifies such things as perseverance, making things, and task completion as being needed to be encouraged, the process of making. 'Time' in relation to completing specific tasks are noted. This is especially important when supported by teachers in praising of completed tasks.

The completion of tasks, the product, required what experienced teachers called 'a sense of urgency'. This means guiding the students to remain focussed upon the task but also allows for students to progress through their learning. The early years guidelines (see Table 14) suggest that children need to explore tools, adhesives and materials before they can use them effectively. This is not restricted to young children, primary school children when given bubble wrap like to 'pop' the bubbles, making sticky balls from glue sticks, and when given a single hole punch for the first-time even some university students like to make little piles of punch blanks. However, being cognisant of the outcomes of the lessons and aware of students need to play with the materials first, the teacher needs to ensure the activity moves along at a brisk pace so that the product is finished in an allocated amount of time. This time allocation is best decided by the teacher and timetables adjusted in order to maximise learning of the children and in the completion of the product. “We have some things that are fixed, so literacy and numeracy blocks are pretty well fixed, non-contact time like physical education, music and geography are fixed, parade is fixed, so I look at it in the timetable that when I’m planning, I do try to integrate subjects” (Interview p. 104).

Here the teacher has a strong sense of what the final outcome will be and then plans to achieve that by prioritizing all the learning and allocating and adjusting times to enable the children to achieve the outcome. At the same time, working with individual children to develop a sense of urgency and moving them along with specific strategies that work for each child.

10.7 Chapter summary

There is no clear scope and sequence in the use of tools, materials and adhesive methods, identified in the data of this study, being used in the primary school; neither in the individual discipline curricula documents nor in the general capabilities of the Australian Curriculum. There was often an expectation that the development of the skills needed were obtained in previous years, or through osmosis and that the rising risks associated with safe and effective use of tools was beyond the capacity of teachers of later years to implement due to restrictions associated with safety and time. The literature indicated that the time needed for children to effectively develop fine motor and manipulative skills and knowledge related to other key learning areas such as arts and technology has been usurped by national and standardised testing in English and numeracy.

The focus on testing and the belief in the separateness of learning disciplines along with a hierarchy of importance, dominated by English and numeracy, demonstrated by the focus on standardised testing regime, has hijacked the time allocations from other subjects, the budgets for other curriculum areas and the professional development of teachers in developing their knowledge of new and emerging tools and materials. Students are tested in the NAPLAN (National Assessment Programme in Literacy and Numeracy) English skills of spelling, grammar, writing, punctuation, reading and reading comprehension, and mathematical numeracy skills in school, state and national tests. The simplistic indicative interpretation of these tests is to highlight short falls in teaching and schools have placed greater emphasis on needing to show individual student progress in English at the expense of STEAM practical skills. To show comparative increase in school’s data, schools are turning to a one size fits all assessment regime of everyone reading the same materials, completing the same tests using the same stimulus with the belief that then the students cannot fail unless the teacher has not taught effectively, leading to a narrowing of teaching and practicing to the do the test. Levitt et al cited in (Conway & Murphy, 2013) reflect similar concerns in England,

> It is plausible that in response to higher demands for accountability, professionals organise their work in a way to meet the targets imposed on them and ‘score’ high in the elements that are being measured and compared in league tables, while not necessarily focussing on the elements that are mostly beneficial for the service recipients (p. 30).

The result of narrowing the curriculum has been not enough time, resources and space given to more hands-on subjects to allow the consideration of basic hands on materials, tools or adhesives which then results in the children having less exposure to these items in the classroom. Children are able to see the progress of their skills in the products they make over time “highlighting how creativity and creative partnership raise aspirations and standards” (Craft et al., 2014, p. 17). Time where they have practiced a skill, discussed the product they have made including identifying what tools, materials and adhesive methods they have used with significant others including parents, teachers, siblings and classmates. Pride in their workmanship is supported by the increasingly complex products that they make reinforcing their self-efficacy.

This chapter provided a discussion on the key themes from the data. The final chapter, chapter eleven, will make recommendations and suggest future study possibilities. It also highlights some of the limitations of the study.

11 Recommendations and Future Possibilities

11.1 Introduction

At its most fundamental level, this introductory exploratory study aimed to identify what tools, materials and adhesives were introduced to primary school aged children and when, being cognisant of their level of physical and cognitive development. Physical development in the context of using tools and materials is based upon the development of fine motor and corresponding gross motor skills, as part of human growth including arm, hand and finger size. These skills involve development of strength, arm-hand, arm-eye, hand- eye, hand-finger, finger-eye, and left arm right arm coordination. Each of these skills need to be developed in the child as they grow as part of a wholistic education that allows connections to be made integrating physical, emotional and cognitive learning. As such, they are part of the rights of the child to a broad education.

11.2 The problems identifying a broad education

Rasinen et al. (2009) stated “Children from grade one onwards - pupils should most importantly gain knowledge about using tools” (p. 374) and have tools at the foundation of their theoretical curriculum analysis model. Lockman (2000) suggested that tool use is a continual developmental process. Cognitive development is enhanced by using appropriate tools and materials related to the eight learning areas especially those associated with science, technology, arts and mathematics.

The rights of all children to a compulsory broad primary education are ensconced in Article twenty-six of the United Nations Universal Declaration of Human rights (United Nations General Assembly, 1948) and this is further endorsed in Articles twenty-eight and twenty-nine in, The Convention on the Rights of the Child (UNICEF, 1989). A broad primary education as stated in article twenty-nine includes “The development of the child's personality, talents and mental and physical abilities to their fullest potential” (UNICEF, 1989). Australia ratified the conventions and announced them in its responses in the Hobart Declaration on schooling (Australian Education Council, 1989) and the Adelaide Declaration (Australian Education Council, 1999). Primary education “is provided for children and is designed to give pupils a sound basic education in reading, writing and mathematics along with an elementary understanding of other subjects such as history, geography, natural science, social science, religion, art and music" (UNESCO, 2007b). Australia responded by creating The Melbourne Declaration on Educational Goals for Young Australians (Ministerial Council on Education Employment Training and Youth Affairs, 2008).

The conventions in the Melbourne Declaration which stated in goal one were to, "promote a culture of excellence in all schools, by supporting them to provide challenging, and stimulating learning experiences and opportunities that enable all students to explore and build on their gifts and talents" (Ministerial Council on Education Employment Training and Youth Affairs, 2008, p. 6). The children of Australia have a right to expect a broad education that encompasses science, technology, arts, health and physical education, languages, humanities as well as English and mathematics.

Basic primary education is not the exclusive domain of reading and literacy, and the failure to develop physical and cognitive growth to the fullest capacity in children and through other disciplines is a cause of concern. Yates and Collins (2010) suggested "Schools have always had other purposes than introducing students to important bodies of knowledge. Primary schools, for example, have been about teaching basic skills and about the development of certain aspects of subjectivity" (p. 94).

School systems, school districts, and individual schools should be wary of stating that the schools do not have to teach broadly because the focus is only on those subjects that are externally assessed. In response to a request to support science in-service for primary teachers, a principal stated, "science is not important" (Personal communication). Neither it seems is technology, a teacher in the interviews explained the result of querying what to do in technology curriculum and school administration responded, 'Oh, don't worry about it. Focus on the literacy, English literacy" (Interview p. 15).

From the definitions of elicited from the previously mentioned documentation of the United Nations and ratified by Australian governments, it was expected that a person being literate in the broad context of the Australian Curriculum goes beyond a singular focus on English literacy. Being able to use noun and verb groups and affixes goes beyond the subject of English. For example, it should include an understanding of applying nouns and verbs relating to naming tools and materials and the actions that they produce such as saws and sawing, drills and drilling. Another example is using prefixes and suffixes such as semi-circle in mathematics, semi-trailer in social studies, semi-conductor in science and semi-breve in music.

However, there is a lack of understanding by some policy makers about of the interconnectedness of various developmental aspects of children's learning and how they are related. The crucial nature of creative learning in primary schools was reinforced by the United Kingdom's 'Creative Partnerships Report' key findings, part of which indicated "evidence of improvement in achievement in areas such as literacy, numeracy and information and communication technology (ICT)" (Ofsted, 2006, p. 4). It further found that the risk taking, communication, collaboration and resilience of children also improved. A change of government in England in 2012 proposed a narrowing of curriculum to focus on national and international testing regimes of literacy and numeracy (Craft et al., 2014). The Queensland curriculum offerings reflected a similar narrowing, because of the 'sharp and narrow focus' on reading and English literacy content knowledge for curriculum. A literature search by this researcher for the concept of "a sharp and narrow focus for reading" However, in the (Department of Education Queensland, 2019) 'Every Child Succeeding' document stated one of our "Priorities- Improve reading and writing for all students" with the objective stating "Focus- on a sharp and narrow explicit improvement agenda" (p. 2).

Part of the problem is the ongoing dilemma of what constitutes a quality education and how best to achieve it within the constraints of time and money. However, "There is a growing concern that education systems are focusing too much on the accumulation of academic "cognitive" skills at the expense of the more elusive and hard-to-measure "non-academic" skills and competencies" (UNESCO, 2016b, p. 1). Harper (2017) suggested in his reflections that teachers are not encouraged to engage with new ideas and risk taking in classrooms, rather they focus more on the implied and explicit messages from education leaders about what learning should look like.

Warning bells for narrowing the curriculum are also hinted at by Alan Finkel (Australia's Chief Scientist) in his notes as chair to the report on Optimising STEM Industry Partnerships, "Industry's motivation …. it wants to elevate the skills and aspirations of the future workforce. This should not be misinterpreted as a desire to replace the broad goals of education with a narrow set of job-specific skills" (Education Council, 2018, p. 8).

11.3 Limitations of the study

This exploratory research had several critical limitations owing to its initial design. The study was instigated out of a concern for the inability of children in a year five class to accurately measure, cut, fold and construct simple automata machines following explicit instructions, that engaged the knowledge, skills and understandings from across several discipline areas. It was assumed that a variety of tools would be introduced to children, with instruction and opportunity to develop competency over the scope of their primary school education from foundation year to year six. These tools would be linked to increasingly complex materials used as required by the curriculum including various adhesive methods, card, fabrics, wood and electronic componentry.

However, from personal in class teaching experience, the students had had little competence, instruction nor practice in the simplest of tools and materials including rulers, scissors, card, wire, PVA, hot glue, and connecting simple circuits, resulting in poorly constructed ineffective products and mechanisms. This was borne out by the teachers involved within this research from the State and Catholic education system schools in the Darling Downs south west regional area of Queensland, Australia. The ability to generalise from beyond the teachers involved in this study is limited and, therefore, may not be representative of all private, Catholic or State schools, nor more remote schools or even the state of Queensland at large.

The results of the study indicate teachers had had little support for engaging with upskilling in physical hands-on activities involving the use of tools, materials and adhesive methods either in pre-service courses or when at schools. Many teachers in the study indicated that they had had no formalised training in the use of tools, materials or adhesives. Whilst this is indicated across all the primary school year levels, the depth of the available responses on the survey was limited due to space and time and the focus of the study. It may be a future point of study to identify more specifically where teachers are learning to safely and effectively use specific tools across each year level, including their understanding of workplace health and safety and risk assessment.

My role as a practising teacher enabled me access to schools through personal contact including schools at which I have taught, in previous years, or where I have provided professional development and skill development. With some of the other schools I visited, I had had no prior contact. Sometimes this access limited responses to statements such as ‘you know’ or only ‘what we did when you were here’, and giving the perceived responses that the researcher wanted, all of which had to be clarified and specific answers confirmed, especially during the interviews. One of the main terms needing clarification was ‘technology’ as it was most often associated with information, communication and technology (ICT) and using computers. The technologies syllabus including its subjects of ‘design technology’ and ‘digital technology’ were discussed in terms of computer use by children.

This was further exacerbated by the questions at the beginning of the survey and teacher’s interpretation of them. The questions asked the teachers to indicate when and where they used the tools, materials and adhesive methods with the children in either an ad hoc manner or in a planned instructional manner. However, some of the responses in the interview indicated that the use of the tools or materials with the children were not part of the process, nor demonstrated to the class but rather shown as a completed product. In the following example the teacher was drilling holes in plastic milk bottle tops to make wheels, “We did that for them before we brought them to school which is probably not good, but we already put holes into them before we bought them in” (Interview p. 33).

The total number of schools (N=12) visited for this research was limited due to time, distance. Whilst seeking to provide for a broad range of size, location and systems, it was limiting in that visiting more like schools would have provided deeper insights into use of tools in the classroom within similar sized schools and classrooms. These insights may have identified and clarified whether the difficulties identified in the study were related more specifically to particular size of schools, locations or expertise of the teachers. Further studies may focus on how schools of different size engage in using tools, materials and adhesive methods including how to access expertise, tuition and professional development.

11.3.1 The survey

In an attempt to identify when tools, materials and adhesives were introduced to children as they progressed through primary school, two avenues were possible. One was to ask teachers what tools and materials they were using in their classrooms each term or secondly for the survey to provide a possible list of tools, materials and adhesives and ask if they use them and when. Each choice had its limitations and the second choice was chosen based upon discussions with peers indicating that teachers were tired and exhausted during the term and at the end of the day a checklist of tools would help them recall what they had used.

This in turn raised the problem of what to put on the survey list for teachers as no list existed in Queensland primary school documents nor Australian school curriculum documentation. There were hints of tools to be used in official curriculum documents associated with the school, region, state and nation. These hints included photos of children using tools, suggestions about the manipulation of materials and ideas for construction of objects for a particular subject, science for example, as in folding aluminium foil to make a boat that floats. Such a list of tools materials and adhesives could be quite substantial requiring more time to complete the survey. Added to this was the local and cultural naming of various items that differed due to the lack of a common vocabulary.

The parameters set in the methodology regarding time to complete and the survey size meant that some items were not on the final list. Some of these were purposefully left off and others by mischance. Scoring instruments such as commercially available plastic spatulas were purposefully left off as handmade and alternative scorers could be used; sticky tape and masking tape were inadvertently left off the final survey. However, these are included in the suggested audit documentation as shown in Table 19 in contribution to the field.

11.3.2 Skill development

From the very first gripping motions of a baby, children develop their fine motor and manipulative skills. The fine motor and manipulative skills from one tool impact on others such as learning how to use a crayon more efficiently and this control links not only to the use of pencils in handwriting but also when using these transverse skills such as in the operation of a scalpel by a doctor. This study did not identify the links between the transference of similar skills between various tools such as the lever cutting action of wire cutters and the gripping action of pliers. This identification of specific skill transference was a limitation in that it could identify that different experiences with different tools would allow for individual primary classes to develop similar skills and concepts.

The specific use of some tools such as wire strippers and electronic components are becoming more important in the development of STEAM skills and contemporary engaging activities such as with wearable technology and robotics. However, initial queries on the survey into knowledge of and skill development of teachers indicated that they had had no instruction themselves in newer more readily available tools, materials and adhesives to accommodate emerging technology. The access to knowledge of skill development in the use of tools by teachers to safely and effectively implement with children in the classroom whilst related to the study was beyond the scope of this research. In the interviews, teachers indicated that the narrowing focus on curriculum from a broad primary school education encapsulated within eight key learning areas to a singular focus on reading and English literacy removed credence and funding from all other learning areas.

General crossover capabilities and skills were also not a focus of attention as shown by standardised academic testing, resulting in time being reallocated to reading and associated commercial products. Science, technology, engineering, arts and mathematics skills relying on development of the child in problem solving, hands-on and using consumable items as well as manipulating tools, materials and adhesives were pushed the background as not important. The physical development of children with regards to fine motor control and manipulating tools and materials in all the STEAM curriculum areas suffered. The focus of the study on a list of tools, materials and adhesives may have been better seen from a developing physical and wellbeing standpoint of the child rather than viewing through a curriculum lens focussing on the opportunities to develop those skills.

11.3.3 General capabilities and disciplines

Another limitation of the broad scope of the study was that it focussed on the entirety of the Australian Curriculum offerings and it may have been better to focus on specific discipline areas and relate them to specific tool use. However, without knowledge of what was available and being used, it would have been difficult to identify cross curricula use. The Queensland and Australian schools were also in the stages of implementing the new versions of curriculum and the specific focus on individual curriculum disciplines such as English, mathematics, science and history and geography. This may have an influence, although it should be noted, whilst implementing the new Australian Curriculum by stages, schools continued to use some State based syllabus documents including the Queensland technology syllabus.

The lack of continual development of skills and competency in tool use across all the primary school years has been noted. It would be interesting in future studies to identify if there was a link observed between the development of manipulative skills in the primary school and future artisan occupations, considering that “Current apprenticeship numbers are in decline” (Torii & O’Connell, 2017, p. 17).

11.3.4 Gender differences

It is noted that there are concerns with not having a more open choice in the selection of gender options in the survey, however the study indicated by Rasinen et al. (2009) does not indicate this variation. Nor does the Queensland College of Teachers (2016) in its annual report that indicates that reported “at the end of 2015; 24.4 percent of registered teachers were male and 75.6 per cent were female” (p. 6). Participants in this study were asked gender as male or female but had the option of not indicating either.

Girls accessing STEM subjects beyond compulsory years are low, and it has been indicated by Rasinen et al. (2009) that female teachers are more likely to teach tools that they are comfortable with. This is reinforced by the curriculum of the 1950’s that indicated that girls were to do needle craft from year 3 and boys could do basketry ('Queensland Department of Public Instruction, 1952, p. 70) There may be a link with tools taught early in the primary school and a difference in male teachers compared to female teachers in the classroom use of tools. The Queensland College of Teachers (2016) stated “female teachers have historically chosen different teacher specialization fields to males” (p. 19). The data needs to be further analysed. An initial comparison of classroom teachers and the number of tools used was found by totalling all the times teachers said they introduced a tool either in an ad hoc manner or developmentally. This data was then grouped by year level and by gender. This was an initial attempt to gain information about the numbers of tools used. An average number of tools was calculated and found to be similar 7.22 tools for female teachers and 7.50 tools for male teachers. The lack of use of some tools used meant that a more effective analysis may be to identify types of tools used by either male or female teachers and link it to their experiences.

Specific tools used by male and female teachers did not show up differences. Some examples are in the use of the guillotine where neither gender instructed in the use of, and 7% females and 9% males indicated use in an ad hoc manner. In the use of wire strippers, 1% of females indicated an ad hoc use and 4% of males indicated use in an ad hoc manner. In sewing needles 10% females indicated and ad hoc use of sewing needles and 14% developmental usage, with males indicating 9% ad hoc usage and 9% instructional. These are very similar when 4% male represents one male teacher.

The lack of male teachers in the classroom is reflected by the somewhat skewed numbers in the collated data. For example, the numbers of male teachers in prep was zero and less than seven percent of teachers in year one was male. Another example of gender difference was shown in the use of Stanley knives shown in Table 13, no female teachers in prep or year one indicated using Stanley knives and one male across prep to year six using Stanley knives in an ad hoc manner. The information is not delineated enough to identify whether the male teacher actually used the Stanley knife in prep of year one. One male teacher in year six indicated both developmental and ad hoc usage, whilst, only two female teachers indicated that they used Stanley knives in each year from year two to six. From this limited information is difficult to make any interpretations of gender influences by teachers

11.4 Curriculum links

Table 18 Curriculum areas linked to tool use

Curriculum/ yr	P	1	2	3	4	5	6
Science	Materials *ACSSU003* Exploring using senses *ACSHE013*	Materials *ACSSU018* Manipulating materials ACSIS025	Manipulating materials ACSIS038 Combining materials *ACSSU031*	Safely use tools ACSIS057 Changes of state of materials *ACSSU046*	Safely use tools *ACSIS066* Natural and processed materials *ACSSU074*	Use materials and equipment safely *ACSIS088*	Use equipment and materials safely ACSIS105 Changes to materials *ACSSU095*
Technology	Use materials and tools *ACTDEP007* Properties of materials *ACTDEK004*			Variety of materials ACTDEP014 Select materials ACTDEP016 Collaborate ACTDEP018 Suitable tools and materials ACTDEK013 Properties of materials ACTDEK012		Investigate tools and materials *ACTDEP024* Safety materials and tools *ACTDEP026* Collaboration *ACTDEP028* Electricity and product *ACTDEK020* Investigate tools and materials *ACTDEK023*	
Arts	Create ACAVAM106 Experiment materials and technologies *ACAVAM107*			Use materials ACAVAR113 Use materials ACAVAM111 Present art works ACAVAR113		Make art works *ACAVAM115* Display art *ACAVAM116*	
Maths		Give and follow directions ACMMOG023 Describe *d*isplay*s* *ACMSP263* measure ACMMG019	Create displays *ACMSP050* Use scales ACMMG038	Measure ACMMG061 Make models ACMMG063	Use scaled instruments ACMMG084 Split common shapes ACMMG088	Pose questions *ACMSP118* Create ACMMG111	Construct ACMMG140

Science, technology, engineering, and mathematics (STEM) are touted as the curriculum content areas needed for moving society in the twenty-first century (Education Council, 2015). STEAM (with the inclusion of the arts) content needs to be engaged with through active participation in problem-based inquiry learning to prepare society's members for life-long learning (Neelands et al., 2015). This journey starts in primary school with children building on experiences from the home, and yet there has been a reduction of time spent in developing these content areas by as much as half the allocated curriculum time. Whilst Australia's Chief Scientist recognises the critical nature of English and mathematics as core subjects, he also relates them to being foundation subjects for the other STEAM areas. "The Mitchell Institute at Victoria University argued that the school systems' focus on content learning rather than a capabilities-focused approach to learning was a problem in developing problem solving" (Laming, 2017, para. 2.5). Zimmerman stated "we have to start thinking about our education system as an ecosystem that starts at pre-primary and goes all the way through to higher education and … we embed these skills right from the beginning" (Laming, 2017, p. para. 2.7). Engineering is not a formal subject in the foundation to year ten Australian Curriculum, but the foundation skills had at its roots, the arts and crafts skills taught in primary school with expectations that children's construction skills and design understanding improve and become more refined with more complex products as they progressed through the primary school years.

The focus on reading and English literacy has nearly doubled its total time allocation in primary schools but it has not doubled the reading and comprehension capacity of children, as indicated by the participants in the study interviews, in fact there is a concerning stagnation in the result in National and standardised testing.

Since 2000, however, academic performance has declined when compared to other Organisation for Economic Co-operation and Development (OECD) countries, suggesting that Australian students and schools are not improving at the same rate and are falling short of achieving the full learning potential of which they are capable. (Gonski, 2018, p. 1)

Children have demonstrated poorer skills in engaging with tools and materials and have lost the ability to consider alternative ideas when engaging with materials in mathematics, art and science. Teachers in the survey and interviews have indicated that they are seeing a down-turn in the engagement of children in learning as a lifelong endeavour and they themselves have a growing dissatisfaction of the teaching profession. There is a sense that the important skills for the twenty-first century such as creativity and innovation are developed through interconnectivity of disciplines. Increasingly, it seems that the ability to integrate learning does not apply to primary teachers as they are forced to follow prescribed texts and assessment tasks. Barton (2014) stated "the C2C materials were encouraged to be used by all state education schools in Queensland and are copyrighted to Education Queensland… The expectation that teachers use this material was particularly evident in ongoing publicity and information sessions prior to implementation" (p. 3). Professional primary school teachers are directed by policy and administrators to present the same content to children, the same way and at the same time, as set down in the C2C, assumedly so that the content can be assessed and compared across all schools across the state through digital data tracking mechanisms.

The general capabilities in the Australian Curriculum that allowed for transverse skills are missing some key points such as physical growth and wellbeing of children. This lack has been noticed by classroom teachers, "ACARA does not have a fine motor component" (Interview p. 14). There is a pervading sadness about education and the direction of primary school education and the failure of systems to consider the whole child and to allow the child time to grow, engage with and reflect upon their world in all its beauty. Teachers in this research study reflect this,

> Sad because I know the benefits of play and lots of children exploring and enjoying being able to make their own mistakes and those types of things and then you feel anxious about having to complete things and having to justify to the principal why we haven't got more children at level X reading and all those things and now with the (commercial program we do) so we'll have to have the data and everything and it's really quite severe about the success of the program. (Interview p. 8).

"I am sad that my [Child] has to go to school in the current environment where creativity is being talked about but is not actually happening in classes" (Interview p. 31).

The decrease in access to science, technology, arts and mathematics subjects through increasing time to accommodate English standardised testing and associated programmes in primary schools has had a negative impact on the children's preparedness in STEAM subjects. Many of the commercially prepared programmes utilised in primary schools have taken time, money and resources allocated to the school for English literacy initiatives that have failed to significantly raise the standard of reading and comprehension. Reduction in resourcing and time means that the children have had limited ability to access tools, materials and adhesives and this has had a flow on effect to other aspects of their learning. Impacts are seen in the lack of development of their fine motor and gross motor skill, control and manipulation of tools and materials. The lack of access and opportunity to sufficient resourcing such as time, staff and consumables has been seen to impact on the safety and quality of their learning across the disciplines. Hunter (2017) suggested that classes sharing insufficient resources caused frustration in children and further wasted time. This then has a negative impact on creativity and innovation.

11.5 STEAM

Limited professional development opportunities for teachers to upskill their knowledge and skills as well as opportunities to engage with conversations on effective pedagogy and activities meant that teachers were unable to provide practical classroom ready resources to the children in their classes. Russell-Bowie (2011) stated "Both in-service and pre-service teachers need adequate personal and professional training in each of the art forms to give them necessary confidence, competence and resources to implement successful arts programmes in primary schools" (p. 171). This was also impacted by the lack of support for teaching safety to children by providing sufficient personnel to assist with the monitoring children's work and safety, and in the collection, maintenance and clean-up of activities that require using tools and materials. An example of this may be found in the support needed for the construction of diorama models such as "students to use balsa wood to make miniature buildings and vehicles for a diorama" (Department of Education Western Australia, 2013, p. 68) which may be used across curriculum areas.

In surveying teachers and students for recommendations Yasin, Amin, and Hin (2018) found teachers listed as their second ranked recommendation "Incorporate more hands-on activities and experiments" (p. 30). The Office of the Chief Scientist (2018) of Australia released a report highlighting the range of STEM initiatives in Australia and suggested that there were many opportunities for school teachers, parents and children to access hands-on STEM related skills and opportunities, both during school and outside school hours, and that many thousands of students had done so.

11.6 Mathematics

Mathematics is a foundation subject for STEM and STEAM which provides understandings for measurement, quantification and analysis skills for engagement with the world at large. The skills and knowledge developed through mathematics provide scaffolding and interconnectedness for science, technology and engineering disciplines. The development of mathematics skills in primary school are highlighted and enhanced when children actively engaged with tools and materials from early years. In discussing active engagement, the Queensland kindergarten learning guidelines suggests that it “provokes exploration, discovery and inquiry by providing new and intriguing materials and resources, such as arts materials and tools and scientific resources” (Queensland Studies Authority, 2010, p. 55). Jamieson-Proctor (2016), a university mathematics pedagogy professor, in lectures to pre-service teachers on such topics as fractions continually enunciates the need to manipulate materials and “cut stuff up”. The interconnectedness of curriculum and its importance in mathematics is highlighted in the Western Australian government programme *First Steps in Mathematics- space* (2013), which suggested “Provide a collection of simple machines (e.g. tin opener, corkscrew, pulley, rocker balance, bike) and invite students to describe the shapes of the component parts and how they move” (p. 61). The learning process has children actively engaging with the artefacts and require suitable time for exploring, examining and engaging mathematics with science, engineering and technology.

The amount of time spent in the arts and previously in arts and crafts in primary school has significantly been reduced over the last twenty years as teachers were forced to remove perceived extraneous activity from the class timetable. Under the guise of emotive terms such as ‘decluttering’, ‘removing the fluff’, and ‘sharp and narrow focus’ many art and craft skills were removed in the belief that a focus on reading and comprehension alone would increase standardised test scores both nationally and internationally. This has led to remedial and prescriptive school programmes often employed by schools.

Discussion with experienced senior teachers has indicated they "find it incredibly sad that this ability to devise curriculum has been taken away from teachers; our profession seems to have been reduced to reproducing a recipe of lessons and carrying out strongly scaffolded and wordy assessment tasks" (Interview p. 110). Learning only specified content knowledge for assessment tasks limits a student's ability to "take considered risk in their decision-making and cope with the unexpected" (Department of Education and Training, 2011, p. 7). 'Risk' does not mean not doing something, rather there is an expectation that as children engage with an activity, teachers have minimised the risks. Educators "are proactive, responsive and flexible in using professional judgments to prevent injury from occurring" (Australian Children's Education and Care Quality Authority, 2018, p. 147) or to minimise the likely hood of injury. Malone (2008) in the report Every Experience Matters, referred to the dangers of over managing risk and to the long term detriment of children's health and well-being. This means that the introduction, use, skill and technological competence of children in the use of tools and materials are developed under the supervision of the teacher managing the safety.

The frame work for curriculum analysis (Rasinen et al., 2009) has three levels each which builds on and develops the next. Level one called "*Technics – by what means*" (Rasinen et al., 2009, p. 5) focusses upon basic knowledge related to tools and how they work. When referring to the technological competence, level one has as its most fundamental the use of tools and machines. Effectively this means that a strong framework could be undermined by a lack of a strong foundation.

11.7 Tools, materials and adhesive methods

This study has sought to identify what tools, materials and adhesives were used in the primary school and factors influencing the opportunities to use them. In seeking to answer the research question several sub-questions were identified. The first question was what tools are currently being used in primary schools, and when are they introduced? With the advent of makerspaces, STEM and STEAM initiatives and the introduction of modern tools and materials such as 3D printers and computer controllers to complement standard construction tools such as scissors and screwdrivers, has the potential to increase interest in learning, creating and innovating by children. This was not the case with teachers indicating a reduction in the type of tools used and the overall time allocated to learning how and where to use and maintain tools. Teachers indicated that the opportunities to use scissors effectively with continuing development of strength and precision does not eventuate. This then has an influence on the materials that could be manipulated and explored by the child. Teachers understanding of the mechanics and requirements of using scissors as shown in the standards video by the Australian Curriculum Assessment and Reporting Authority (2018b) demonstrated practical and hands on errors.

The banding of year levels in the Australian Curriculum allowed for schools and systems to introduce a disjointed approach to the development of discipline knowledge which impacted negatively on fine motor manipulative skills development. That meant that there was not a smooth developmental progress in the child's strength and coordination needed for the safe and efficient use of tools.

The second research sub question asked what materials are currently being used in primary schools, and when are they introduced? The availability and accessibility of resources through local community stores and online allow for new and innovative opportunities to engage students in the design and making process. "More diverse lot of materials you know the junk shop in Brisbane where you can ring up" (Interview p. 24). This may mean that the funding and storage to access to materials is a problem in schools. However, the demise of tools in the classroom with which students could manipulate and transform materials into new and creative products has meant less engagement with these materials, with the result they are no longer on hand to be used in the classroom. This lack access to a wide variety of materials and with integrating new material technology is compounded by teachers and students failing to have the skills and competencies needed to effectively capitalise on modern technologies such as wearable technologies. The materials that needed more robust cutting and manipulative tools were no longer used where once they were used in preschool. Saws, drills and pliers were not highlighted as being used in primary schools in the survey and therefore it was no surprise that wood, metal and electronic components were also missing. Light emitting diodes (LEDs) and computer controllers are all part of the modern world, and the integration of these newer tools and materials integrated with the more traditional materials and tools provide an exciting and rich opportunity for children to engage with. Children need to develop a sense of responsibility for the quality of their work that develops under the guidance of the teacher.

The use of adhesive methods to join materials and other resources was the focus of the third question in this study. The introduction of the glue stick into the primary classroom seems to buck the trend of implementing modern adhesive methods; however other modern adhesive methods seem to have been lost to the primary classroom. Hot glue, when it is used in the classroom is by observation only. The fear of children burning their fingers has stopped potential learning for the use of this medium. Some middle and upper primary school teachers indicate that they have never used a hot glue gun and never had instruction in its use. The use of PVA or wood glue has seen a demise in the primary classroom due to costs, mess and possible allergies. The downturn in the use of wood and metals has meant that items such as nails, screws, nuts and bolts have also disappeared from the primary classroom. Much of this decline is also linked to the understandings of the teachers. Less than three percent of the teachers surveyed indicated that they had any formal training in the use of tools, whilst more than fifty-four percent of teachers indicated that they never had any training in the use of tools.

The use of tools, materials and adhesive methods in the modern classroom needs the upskilling of all staff in the school to be current. Teachers and teaching assistants need to be provided with opportunities to engage with and gain proficiency in traditional and modern tools and materials, including how to use them safely and to consider best pedagogical practices when using them with children. Teachers and assistants need space in the classroom for storage of tools and materials, maintenance and replacement of class sets of tools and to provide opportunities to share the fruits of the children's labours with the community.

11.8 Contribution to the field

The survey from this study formed the basis of a list of recommended tools, materials and adhesive methods for primary schools. The recommended list contains suggested tools, materials and adhesive methods and be developed through further discussion with teachers for each year level with associated skills and links to the Australian Curriculum. This revised and updated total list will provide schools an audit tool to assist in the effective implementation is shown in the following sample of Table 19. A full selection is provided in appendix 5.

Table 19. *Audit tool for schools.*

Year level		Quantity	term 1	term 2	term 3	term 4	specific skill taught
knives	plastic						
metal	Butter						
	Stanley						
	box/ razor						
	Scalpel						
	Bread						
scissors	Safety /blunt nose						
	fancy cut						
	shears - card						
	pinking shears						
saws	Tenon						
	Hand						
	Fret						
	Hack						

11.9 Future research

In order to adequately address the developmental needs of the whole child, classroom teachers must be seen as the professionals they are and equal partners with parents and other professionals in the development of children in their formal learning. “Beyond what parents can do at home to encourage children’s development, they can be allies in efforts to strengthen capabilities in formal education” (Lucas & Smith, 2018, p. 10). Primary teaching is a profession that needs lifting in the eyes of the community, as well as acceptance of their expertise, and this could be achieved by ensuring that all principals have the highest levels of qualification and experience available in teaching young children. Research could identify how the developmental needs of children change from preschool through to high school especially through the general capabilities as well as how the fine motor skills develop in parallel to discipline knowledge. How much resourcing and support is directly controlled by professional primary school teachers engaged to face to face teaching, such as teacher aide allocation. Principals need to ensure that all the teaching assistants are gaining skills as well through appointing the highest qualified teaching assistants, leading to the question what requirements are in place for teacher aide qualifications?

The access to modern skills and technological tools requires time, funding and resources be available to be engaged with by primary school teachers. One of the biggest factors influencing the introduction and development of tools, materials and adhesives in the classroom was the loss of time for banded subjects due to imposition of excessive standardised testing in literacy. An audit and rethink of the disadvantages of overly assessing children on standardised testing by non-school based personnel needs to be carried out.

Currency of teacher knowledge and skills must come from the teacher identifying their needs and not be imposed by outside bodies. Skill development opportunities should be enhanced by encouraging teachers and teacher aides to regularly attend conferences, symposium or seminars to maintain currency of skill in their areas of teaching, and to consider new ideas and pedagogy and develop shared professional learning networks. These networks should allow for increasing confidence and comfort by teachers in the classroom application of using tools, materials and adhesive methods.

The final consideration for the section on future research would be in the refinement and development of a scope and sequence chart for the use of tools, materials and adhesive methods used in the primary school. This scope and sequence could be based upon the audit tool developed from this study. It could be elaborated upon to show closer links to how tools, materials and adhesive methods may be used in each year level and show the manipulative and fine motor skills are developed and linked across the curriculum . It could also show how the use of tool, materials and adhesive methods could enhance learning across integrated learning areas and how the fine motor skills are developed across the banded curriculum year levels using the links to table 19.

11.10 Recommendations

This initial exploratory study highlighted several important issues with regards to providing a broad primary education supporting growth of cognitive levels of children through use of hands on tools and materials. As a result of the careful analysis of this research data there are eight recommendations to be made to education systems, schools and teachers and future research. These recommendations overlap each section, however, recommendations one through five should be considered by education systems. Recommendations three through seven should be considered by schools, and recommendations five through nine should be considered by teachers..

11.10.1 Recommendation one

Given the lack of specificity in the naming of tools, materials and adhesives a list of tools, materials and adhesives identified as being used in primary schools be developed from the survey for schools to use as an audit tool. A sample of this is given in Table 19 with a fuller list in Appendix 5.

11.10.2 Recommendation two

Given the lack of alignment between curriculum expectations in STEAM subjects as highlighted in and the ways that teachers have reported using (and not using) materials, tools and adhesive methods in this study, it would be helpful to review the alignment of tools, materials and adhesive methods in the primary school across all the curriculum discipline areas especially those related to science, technology, arts, and mathematics (STEAM) to allow children multiple opportunities to engage with appropriate tools at their level with increasing confidence building their self-esteem and sense of responsibility.

11.10.3 Recommendation three

Accessibility to space and storage of materials and products in development is highlighted in chapter 4.1. Therefore it is recommended to have school spaces set aside to store and manage resources in the primary school and for the safe storage of class tools, materials, adhesives and developing projects in the classroom and for the display of exemplary works by every child, showing each child's progress.

11.10.4 Recommendation four

The lack of experience in the use of tools as highlighted in Table 4 and associated professional development as noted in Table 5 would indicate a recommendation to provide opportunities for teachers to engage in professional development in the use of all tools and materials relevant to their needs and the needs of their students.

11.10.5 Recommendation five

Following on from recommendation four and the links teachers have indicated with in the area of safety in section 10.3 adult support it is recommended that teacher aides are also upskilled. The qualifications and skills of teacher aides should be regularly and formally updated to include child development understandings, tool and material use, curriculum awareness and safety. This would allow for teachers to be more comfortable around tools and to allow children opportunities to engage in new tools and to practice their own skill development.

11.10.6 Recommendation six

Section 10.6 of this study highlights the need for time to be spent introducing and practicing with a variety of tools across the curriculum. These have been highlighted in Table 19. Recommendation six would be to audit the actual amount of time allocated to each learning area to ensure all curriculum areas have enough time to develop and use tools, materials and adhesives across all subjects to allow for the development of the child to their fullest potential.

11.10.7 Recommendation seven

Using the audit tools from the survey and table 19 to identify appropriate school year levels for introducing the tools, materials and adhesive methods then it would be possible to identify a series of sample year by year hands-on skill developmental activities be created to provide teachers with skill development that allows them to gain confidence and comfort in using tools, materials and adhesive methods, whilst showing a connected integrated way of applying curriculum discipline knowledge. The activities should be able to be modified by the teachers to encourage the child's curiosity, enthusiasm, creativity, collaboration and communication and that these activities be constructed over a graduated period of time depending on the year level and capabilities of the child.

11.10.8 Recommendation eight

Following on from recommendation to develop their skills in using a variety tools, materials and adhesive methods the next recommendation would be that all students make a hands-on physical product every semester in the primary school that that engages tools and materials as needed to develop their physical dexterity and competence, including fine motor skills. As well as specifically encouraging children to develop confidence and pride in their work with quality items produced as discussed in Rasinen et al. (2009) who suggested children "work with tools, equipment, materials and components to make quality products" (p. 35). These products may be developed across an integrated range of curriculum areas such as science, technology, engineering, arts and mathematics. The final products would then be presented to the child's peers, family and community as a celebration of the child's creativity, risk taking, resilience and collaboration similar to the creative partnerships initiative (Ofsted, 2006).

11.11 The future and STEAM

The active participation of children in their learning throughout primary school will be enhanced by engaging with hands-on traditional and modern tools, materials and adhesive methods. These tools, materials and adhesives engage gross and fine motor manipulative skills through a sequential and developmental progression across all the primary school years. Davies et al. (2013) recommended that when teachers are planning classroom practice, consideration be given to 'critical events' that encourage creative endeavours beyond single classroom activity. Every year level and every semester must include all children making or constructing a product to the best of their ability using tools and materials implemented at each year level.

The teacher's role and the communities they work in are changing, but the focus is still on providing the best opportunities for children to grow as creative, innovative problem-solving members of society. Teachers are best placed to identify students who are struggling with cognitive and physical difficulties in their classes as they have daily contact with them. Developmental guidelines created by other agencies should be linked with teachers' observations showing when children are acquiring and demonstrating age appropriate skills. Other agencies, including health, welfare, and housing services, can also improve the circumstances and school readiness of developmentally vulnerable children (Gonski, 2018).

Whilst many studies have focussed upon the links between gross and fine motor skills and cognitive and social development, studies could also be considered on specific skills and the links to transversal competencies through problem-based activities. An extension to these future studies may also consider the impact of not doing these activities using tools, materials and adhesives especially on vocational occupations using trade skills and apprenticeships. An example might be to track if there a link to declining number of students interested in vocational studies or becoming carpenters and artists and such.

11.12 Summary

There is an underperformance in the competencies and capabilities of children in using everyday tools, materials and adhesive methods in many classrooms today. Due to the need to support children's physical growth during the primary school years it is essential that the children have experiences that allow them to develop their fine motor skills and control including manipulating tools and altering materials. The study was expected to locate what, when and where tools, materials and adhesive methods were introduced. With the possible exception of some mathematical tools, there was no discernible pattern of introduction of tools and materials in the primary school. The development of skills and active use of tools, materials and adhesive methods including modern technological tools was not a priority. This research study identified that support given to teachers through curriculum direction and supporting documentation was limited. Specific expectations of physical development and use of tools, materials and adhesives to enable children to fully engage with the various disciplines within the curriculum was inadequate. The problem identified was that there was no guidance in when or which tools, materials and adhesives were introduced, nor how the fine motor and associated gross motor skills were developed across the curriculum. This research indicated that a lack of guidance in incorporating hands-on experiences impacted negatively on children's engagement, persistence and pride in learning. As they grow older, children are not reaching their full potential to create, innovate and to become more efficient and competent in a broader range of knowledge and skills.

The seemingly growing aversion by some people (including administrators involved with education and primary schools), with engaging with tools and materials led me to develop a survey to ascertain a current picture of primary practice. Analysis of the study was expected to explore the opportunities children had to gain competence and confidence in the use of tools and materials. What the study showed was that children are doing less and less actual hands-on activities with traditional tools, materials and adhesive methods and not engaging with newer technologies and resources. Teachers are hampered by narrow policy interpretations, time limiting pedagogies, funding, access and fear of causing injury to children, and at the same time negating their duty and legal responsibility to ensure that every child reaches their full potential across a broad primary education.

Therefore, if we wish to have a creative innovative workforce for the future well-being of the Australian nation there needs to be an increased emphasis on children in primary schools engaging with tools, materials and adhesive methods, as they develop their interest, engagement and deeper understandings of the STEAM discipline areas. This engagement should show continual development across every year level both with the skill and dexterity in the use of the tools and materials, and in the range and complexity of tools being used across the curriculum areas. Even creative individuals such as Picasso start out with manipulating tools and materials.

> It is a known fact that ever since he was a child Pablo Picasso enjoyed making cut-outs with pieces of paper and scissors. It is perhaps from his desire to construct and transform materials into figures, he developed his talent for conjuring artworks using images, fragments, objects and materials from a variety of sources. It led to the use of collage in his work and his numerous experiments on occupying 3D spaces using various sculpture techniques. He was a skilled craftsman and took advantage of any materials he came across; wire, cardboard, plaster, clay, wood and so on; using this skill of cutting and folding that he learnt as a child. (MuesoPicassoMalaga, 2017)

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13 Appendices

13.1 Appendix 1

Australian Curriculum with elaborations recorded

Curriculum/ year	P	1	2	3	4	5	6
Science	Materials *ACSSU003* Exploring using senses *ACSHE013*	Materials *ACSSU018* Manipulating materials ACSIS025	Manipulating materials ACSIS038 Combining materials *ACSSU031*	Safely use tools ACSIS057 Changes of state of materials *ACSSU046*	Safely use tools *ACSIS066* Natural and processed materials *ACSSU074*	Use materials and equipment safely *ACSIS088*	Use equipment and materials safely ACSIS105 Changes to materials *ACSSU095*
Technology	Use materials and tools *ACTDEP007* Properties of materials *ACTDEK004*			Variety of materials ACTDEP014 Select materials ACTDEP016 Collaborate ACTDEP018 Suitable tools and materials ACTDEK013		Investigate tools and materials *ACTDEP024* Safety materials and tools *ACTDEP026* Collaboration *ACTDEP028* Electricity and product *ACTDEK020*	

<table>
<tr><td></td><td colspan="3"></td><td colspan="2">Properties of materials ACTDEK012</td><td colspan="2">Investigate tools and materials ACTDEK023</td></tr>
<tr><td>Arts</td><td colspan="3">Create ACAVAM106
Experiment materials and technologies ACAVAM107</td><td colspan="2">Use materials ACAVAR113
Use materials ACAVAM111
Present art works ACAVAR113</td><td colspan="2">Make art works ACAVAM115
Display art ACAVAM116</td></tr>
<tr><td>Maths</td><td></td><td>Give and follow directions
ACMMOG023
Describe displays ACMSP263
measure
ACMMG019</td><td>Create displays ACMSP050
Use scales
ACMMG038</td><td>Measure ACMMG061
Make models
ACMMG063</td><td>Use scaled instruments
ACMMG084
Split common shapes
ACMMG088</td><td>Pose questions ACMSP118
Create ACMMG111</td><td>Construct
ACMMG140</td></tr>
</table>

(Australian Curriculum Assessment and Reporting Authority, 2018a)

13.2 Appendix 2 Sample Survey Form

Table 20

Sample Survey Form

Tools in the classroom

Tool use in the Primary School is mentioned in various Australian Syllabi though not necessarily specifically by name. Please indicate what tools the children use and when they may use these tools. If you do not use tools in your classroom please just indicate year level and return form. If you wish to make a comment please do.

No.School Children	Year level taught	Are you	Years teaching	Please tick which term children use tools in your class.	Subject most associated with
< 60 ☐ <100 ☐ <300 ☐ <500 ☐ >500 ☐		Male ☐ Female ☐ Class size		**Ad hoc - means you use with particular activity though do not plan for the instruction of tool use** **Planned - includes instruction in use, handling and safety in the use of.** **Never - means you don't use these tools with this class.**	**.M maths** **.A arts** **.S science** **.T technology** **.O other**

Choose either Ad hoc or planned		**Ad hoc** use of tools,					**Developed planned** use of tools				
Tool type	Name of Tool	Never	Term 1	Term 2	Term 3	Term 4	Term 1	Term 2	Term 3	Term 4	Please circle as appropriate
Cutting	Safety scissors										M A S T O
	Surgical scissors										M A S T O
	Fancy cut scissors										M A S T O
	Pinking shears										M A S T O
	Guillotine										M A S T O
	Rotary trimmer										M A S T O
	Stanley knives										M A S T O
	Box cutter/ razor knife										M A S T O
	Scalpels										M A S T O
	Fret saws										M A S T O
	Tenon saws										M A S T O
	Hack saws, metal saw										M A S T O
	Electric scroll saw										M A S T O
	Electric jig saw										M A S T O
	Laser cutters										M A S T O
	Side cutters										M A S T O
	Wire strippers/ cutters										M A S T O
	Lino cutters										M A S T O
Hole making	Double hole punch paper										M A S T O
	Single hole punch paper										M A S T O
	Leather punch										M A S T O
	Hand drill										M A S T O
	Electric drill										M A S T O
	Awl										M A S T O
	Sewing Needle										M A S T O
	Circle (Compass) cutter										M A S T O
Manipulative	Hammer										M A S T O
	Long-nose pliers										M A S T O
	Snub-nose pliers										M A S T O
	Clamps										M A S T O
	Tweezers										M A S T O
	Multi grips										M A S T O
	Spanners										M A S T O
	Phillips screw driver										M A S T O
	Flat blade screw driver										M A S T O
Measuring	Ruler										M A S T O
	Tape measure										M A S T O
	Maths Compass										M A S T O
	Dividers										M A S T O
	Protractor										M A S T O
Other	Paint roller										M A S T O
	Water colour paint brush										M A S T O
	Varnish paint brush										M A S T O

Materials in the classroom

Material use in the Primary School is mentioned in various Australian Syllabi though not specifically by name. Please indicate what materials the children use and when they may use these materials.

Please tick in which term you use materials		Ad hoc use of materials					Developed planned use of materials				Subject most associated with
Type	Name of materials	Never	Term 1	Term 2	Term 3	Term 4	Term 1	Term 2	Term 3	Term 4	Please circle
Paper	Photocopy paper A4										M A S T O
	Photocopy paper A3										M A S T O
	Photocopy card A4										M A S T O
	Photocopy card A3										M A S T O
	Tissue paper										M A S T O
	Straw board										M A S T O
	Corrugated card										M A S T O
	Cartridge paper										M A S T O
	Papier Mache										M A S T O
	Butcher's paper										M A S T O
Plastic	Cling wrap										M A S T O
	Acetate sheet										M A S T O
	Flute Board, Foam core										M A S T O
	Perspex										M A S T O
	Cellophane										M A S T O
	Plasticised gift wrap										M A S T O
Cloth	Calico										M A S T O
	Hessian										M A S T O
	Poly cotton										M A S T O
	Canvas										M A S T O
	Rayon										M A S T O
	Faux fur										M A S T O
	Sponge										M A S T O
	Wool										M A S T O
Wood	Balsa sheet										M A S T O
	Balsa block										M A S T O
	MDF										M A S T O
	Laminate										M A S T O
	Pine										M A S T O
	Red cedar										M A S T O
	Hardwood										M A S T O
	Match sticks										M A S T O
	Paddle pop sticks										M A S T O
Metal	Copper sheet										M A S T O
	Aluminium foil										M A S T O
	Aluminium sheet										M A S T O
	Tin plate										M A S T O
	Multicore wire										M A S T O
	Single core wire										M A S T O
	Pipe cleaners										M A S T O
Electronic	Lighting components										M A S T O
	Switching components										M A S T O
	Connecting component										M A S T O
	Sound components										M A S T O
	Sewing machine										
Other											M A S T O

Adhesive Methods in the Classroom

Adhesive methods include any method of attaching two objects together including tacks, pins, wire and glue. Some need a tool to operate such as rivets.

Choose either Ad hoc or planned		Please tick in which term you use adhesives									Subject most associated with
		Ad hoc use of adhesives					Developed planned use of adhesives				
Type	Name of adhesive method	Never	Term 1	Term 2	Term 3	Term 4	Term 1	Term 2	Term 3	Term 4	Please circle
General	Nails										M A S T O
	Screws										M A S T O
	Desk Stapler and staples										M A S T O
	Plier stapler										M A S T O
	Soldering iron and solder										M A S T O
	Nuts and bolts										M A S T O
	Rivets and rivet gun										M A S T O
	Hot glue gun and glue										M A S T O
	Pins										M A S T O
	3D printer										M A S T O
	Paper clips										M A S T O
	String										M A S T O
	Wire ties										M A S T O
	Plastic ties										M A S T O
	Safety pins										M A S T O
	Sewing pins										M A S T O
	Velcro										M A S T O
	3D Pen										M A S T O
Glues	Glue stick										M A S T O
	Acetate glue										M A S T O
	PVA wood glue										M A S T O
	Clag										M A S T O
	Clear Gum										M A S T O
	Split pins										M A S T O
Safety	Eye protection										M A S T O
	Ear protection										M A S T O
	Clothing										M A S T O
	MSDS										M A S T O

Professional Development

Training engaged with	Never	Self-Taught	Uni. TAFE	In last year	In last 5 years	> 5 years	Comment
Tools							
Materials							
Adhesive methods							
Safety with Tools, Materials Adhesives							
Commercial construction kits							

Confidence in use of	Very low	Low	Average	High	Very high	Comment
Tools						
Materials						
Adhesive methods						
Safety						

Using tools, materials and adhesive methods in your classroom.

There are many factors that influence the use of tools in the primary school including materials, teacher beliefs, safety, storage, space, time, teacher confidence and experience, and accessibility to tools. Please write a brief statement or comment of some of influencing factors you feel are most important to you in the introduction and use of tools in your classroom. Please feel free to add more comments.

Please indicate enablers to using tools, materials and adhesives in your classroom.
What tools and materials would you like to use in the classroom, why?
What tools and materials do you like using in the classroom, why?
What resourcing would you need to be able to do this?
Please indicate inhibitors to using tools materials and adhesives in your classroom.
Please indicate an activity, task or lesson that you set in your classroom that involves children engaging with tools, materials and adhesives and indicate what tools and materials they may use to complete the task.
Any other comments.

13.3 Appendix 3 Permission letters

Queensland Government

Department of
Education and Training

26 October 2015

Attention Principal
Darling Downs South West Region

Dear Colleague

Mr Alwyn Powell from the University of Southern Queensland has the Department's approval to approach your school inviting participation in research titled "*Identifying tools, materials and adhesive methods used in the primary school and factors influencing the opportunities to use them*". The acceptance of the invitation to participate is entirely voluntary and at your discretion.

This letter provides you with information about the Department's terms and conditions for research conducted on state school sites to inform your decision as to whether or not your school will participate in this research. The Department supports the conduct of quality research in State schools and values the potential contribution of good research in informing educational policy and professional practice. Participation in research, however, may impact on the daily operations of schools, and it is therefore imperative that discretion is used when deciding whether to agree to research involving your school.

As a minimum, the researcher should provide you with the following documentation to inform your decision regarding school research participation:

- an information statement which describes the research, identifies who will be involved (e.g. students, teachers, parents/caregivers) and explains what will be required of these participants
- the informed consent form for you to sign to indicate your agreement that school staff can be invited to participate in the research
- a copy of the approval to approach letter from central office or regional office (where applicable)
- a copy of the final ethical clearance from their institution's Human Research Ethics Committee
- full copies of any data collection instruments such as surveys, questionnaires, and interview schedules to be used in the study

Most importantly, participation in any research is voluntary, and you have the right to decline your school's participation in a research project, even if approval to approach your school has been granted at regional level. It is also recommended that you monitor any research activities conducted in your school and you may, if you wish, withdraw your support for the research study at any time without penalty.

Darling Downs South West Region
178 Hume Street
PO Box 38 TOOWOOMBA
Queensland 4350 Australia
Telephone (07) 4616 3771
Website www.dete.qld.gov.au

At the conclusion of research involving your school, the researchers are required to provide the department with a written report summarising the main findings of the study.

Should you require further information on the research application process, please feel free to contact Kylie Dowdle, Principal Advisor Regional Services on (07) 4616 7601.

Yours sincerely

Greg Dickman
Regional Director
Darling Downs South West Region

From

Alwyn Powell

Doctoral Student

University of Southern Queensland

Baker Street, Toowoomba, 4350

To The Principal

Many thanks for allowing me to engage with your teachers as part of my doctoral studies. I have permission to approach your schools from the directors of the local region as well as having Ethics approval from The University of Southern Queensland.

The permissions are from

- USQ Ethics H15Rea212 16th October 2015
- Joe Borserio Diocese of Toowoomba 2nd November 2015
- Greg Dickman Darling Downs South West Region 26th October 2015

As part of the study I am required to keep a record of your approval to approach your school. This is the informed consent form for you to sign to indicate your agreement that school staff can be invited to participate in the research. Therefore could you please sign this letter indicating that I have sought your permission as well as providing the relevant information statement, and sample of the research documents, .

Many Thanks

Alwyn Powell

I hereby acknowledge an approach by Alwyn Powell to conduct research in my school at a time mutually acceptable to all parties. Further I have been supplied with appropriate supporting documentation.

Name...

Principal

School name/ stamp ....

Date ..../..../........

University of Southern Queensland

Consent Form for USQ Research Project Interview

Project Details

Title of Project:	Identifying tools, materials and adhesive methods used in the primary school and factors influencing their use
Human Research Ethics Approval Number:	H15REA212

Research Team Contact Details

Principal Investigator Details
Mr Alwyn Powell
Email: alwyn.powell@usq.edu.au
Telephone: (07) 46312132
Mobile: 0418766628

Supervisor Details
Professor Peter Albion
Email: Peter.albion@usq.edu.au
Telephone: (07) 4631 2321

Statement of Consent

The list of tools in the survey has tools that may not be used in you class or year level. The list contains tools materials and adhesives that may be used right across the formal education year levels. It is not expected that you will use all or any of the listed tools.
All data collected will be only handled by the researcher and specific data will be collated to maintain anonymity of both participant and school. The interview time anticipated is thirty minutes.
By signing below, you are indicating that you:

- Have read and understood the information document regarding this project.
- Have had any questions answered to your satisfaction.
- Understand that if you have any additional questions you can contact the research team.
- Understand that you are free to withdraw at any time during the interview but not after coding.
- Understand that all data will be treated confidentially.
- The interviews will be recorded and codified by the Principal Investigator (Alwyn Powell) only.
- Understand that you can contact the University of Southern Queensland Ethics Coordinator on (07) 4631 2690 or email ethics@usq.edu.au if you do have any concern or complaint about the ethical conduct of this project.
- Are over 18 years of age and agree to participate in the interview.

Participant Name	
Participant Signature	
Date	

Please return this sheet to a Research Team member prior to undertaking the questionnaire.

Version 2.0 18/02/14

Expected Benefits

It is expected that this project will directly benefit your school with a clearer understanding of tool, material and adhesive use in primary schools.

Risks

There are no anticipated risks beyond normal day-to-day living associated with your participation in this project.

Privacy and Confidentiality

All comments and responses will be treated confidentially. The anonymous surveys will be kept under password at USQ for the required fifteen years, and will not be used for any other purpose other than the doctoral thesis. Alwyn Powell will be the only person handling the surveys.

Any data collected as a part of this project will be stored securely as per University of Southern Queensland's Research Data Management policy.

Consent to Participate

The return of the completed questionnaire is accepted as an indication of your consent to participate in this project.

Questions or Further Information about the Project

Please refer to the Research Team Contact Details at the top of the form to have any questions answered or to request further information about this project.

Concerns or Complaints Regarding the Conduct of the Project

If you have any concerns or complaints about the ethical conduct of the project you may contact the University of Southern Queensland Ethics Coordinator on (07) 4631 2690 or email ethics@usq.edu.au. The Ethics Coordinator is not connected with the research project and can facilitate a resolution to your concern in an unbiased manner.

Thank you for taking the time to help with this research project. Please keep this sheet for your information.

University of Southern Queensland

UNIVERSITY OF SOUTHERN QUEENSLAND AUSTRALIA

Participant Information for USQ Research Project Questionnaire

Project Details

Title of Project:	Identifying tools, materials and adhesive methods used in the primary school and factors influencing their use
Human Research Ethics Approval Number:	H15REA212

Research Team Contact Details

Principal Investigator Details

Mr Alwyn Powell
Email: alwyn.powell@usq.edu.au
Telephone: (07) 4631 2132
Mobile: 0418766628

Supervisor Details

Professor Peter Albion
Email: peter.albion@usq.edu.au
Telephone: (07) 46312321

Description

This project is being undertaken as part of the Doctoral program.

The purpose of this project is to identify what tools, materials and adhesive methods are used in the primary school and factors influencing their use.

The research team requests your assistance because currently there are no indications of what tools, materials and adhesive methods are being used in the primary school and with the advent of the new Australian curriculum stating their use it is necessary for supporting teachers with resourcing and skill development to know what is used.

Participation

Your participation will involve completion of a questionnaire that will take approximately 15 minutes of your time.

Questions will include
What tools you have used in the last twelve months?
When you introduced them?
And if you had any training in them.

Your participation in this project is entirely voluntary. If you do not wish to take part you are not obliged to. If you decide to take part and later change your mind, you are free to withdraw from the project at any stage. Please note, that if you wish to withdraw from the project after you have submitted your responses, the Research Team are unable to remove your data from the project.
Your decision whether you take part, do not take part, or to take part and then withdraw, will in no way impact your current or future relationship with the University of Southern.

Research Guidelines

for applicants wishing to conduct research in Diocese of Toowoomba Catholic Schools

Introduction

The Diocese of Toowoomba Catholic Education is committed to the creation and maintenance of positive and safe working and learning environments and the provision of high quality Catholic education. Therefore, we welcome research in our schools that assists in fulfilling this mission.

Diocese of Toowoomba Catholic Education is a system of 31 schools[1] catering for approximately 9 000 students spread across rural areas that include Quilpie, Cunnamulla and Goondiwindi, and regional centres such as Roma, Dalby and Warwick and Toowoomba.

All applications to conduct research in Diocese of Toowoomba Catholic Education schools are to be made to the Executive Director, Catholic Education Office through the Diocese of Toowoomba Catholic Education Office.

Please note: Any applications to conduct research made directly to schools will be redirected to the Executive Director, Catholic Education Office.

Any approval granted, by the Executive Director, to conduct research in any of the Diocese of Toowoomba Catholic Education schools is in-principle only. The final decision to allow the proposed research to be conducted in the school resides with the school principal.

Finding Catholic Schools

These research guidelines only apply to research that is undertaken within Catholic schools governed by the Diocese of Toowoomba Catholic Education Office.

Diocese of Toowoomba Catholic schools

A list of Catholic schools located within the Diocese of Toowoomba is published at www.twb.catholic.edu.au under "Our schools".

Other Dioceses

There are a total of five Catholic dioceses within Queensland. A list of Catholic schools in each of these Dioceses can be accessed through the Queensland Catholic Education Commission website (www.qcec.catholic.edu.au)

All applications to conduct research in Catholic schools governed by other Dioceses should be directed to the Executive Director of Catholic Education in the appropriate diocese.

Applications to conduct research in Religious Institute schools (independent Catholic schools administered by religious orders) must be addressed separately and directed specifically to the principals of these schools.

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[1] Please note: Downlands College and St Ursula's College are Religious Institute schools and are not governed by the Diocese of Toowoomba Catholic Education. Research in these schools will need to be approved through direct contact with the school Principal.

Research approval procedure

- The Principal Researcher is to complete and send all required documentation (as listed below) to the ***Executive Director, Catholic Education Office, PO Box 813, Toowoomba, 4350.***

Required documentation

- Completed Form A - Research Proposal
- Completed Form B – Confidentiality declaration by Principal Researcher
- Completed Form C – Confidentiality declaration by Assistant Researcher
- Completed Form D - Agreement to provide research findings to Diocese of Toowoomba Catholic Education Office
- Completed Form E - Research Approval for undergraduate and postgraduate students OR Copy of Ethical Clearance Approval from the University
- Copy of a valid Positive Notice Blue Card as issued by the Public Safety Business Agency or evidence that an exemption applies

- If all documentation is provided at the time of application, the Principal Researcher can expect to receive a Response within two to three weeks.

- The Executive Director, Catholic Education Office will send a letter of in-principle approval to approach the principal/s at the respective school/s.

- A copy of this letter and the research application forms will also be sent to the principal/s of the named schools by the Executive Director, Catholic Education Office.

Research approval conditions

General

- In submitting the research proposal, researchers agree to comply with the procedures and conditions outlined within these guidelines.

- Researchers conducting research within Diocese of Toowoomba Catholic Education schools must ensure that their research does not negatively impact on the teaching and learning environment of the school/s.

- All required documentation is to be provided at the point of application by the Principal Researcher.

- Diocese of Toowoomba Catholic Education will not provide approval for research which is undertaken primarily for commercial or material gain.

- Upon completion of the research, the researcher will:
  - provide Diocese of Toowoomba Catholic Education Office with a copy of the research findings
  - provide the schools in which the research was conducted with a summary of the research findings.

- Unpublished reports from research pertaining to individual case studies conducted with students in Diocese of Toowoomba Catholic schools are to be given directly to the principal of the school.

Specific conditions for undergraduate and postgraduate courses

- Ethical approval may not be required for all research assignments that are a part of undergraduate and postgraduate courses. In such cases, **Form E "Research approval for undergraduate and postgraduate students"** is to be used in the application to undertake research.

Specific conditions for employees of Diocese of Toowoomba Catholic Education

- Employees of the Diocese of Toowoomba Catholic Education who conduct research in Diocese of Toowoomba Catholic Education schools, in the course of employment and as part of their usual duties, and publish this research are to note that the first owner of copyright will usually be the Diocese of Toowoomba Catholic Education Office, as the employer.

Legislative and policy conditions

Privacy and Confidentiality

- Diocese of Toowoomba Catholic Education is bound by the Australian Privacy Principles contained in the Privacy Act 1988 (Cth).

Please note If a research participant discloses to a researcher, confidential information in relation to sexual or physical abuse/harm or circumstances where a student's health, safety or well being is in danger, the researcher is required to disclose this information to the school principal immediately.

Student Protection

- Researchers making application to conduct research in Diocese of Toowoomba Catholic Education schools whose research involves working with children under 18 years of age are required to contact the Public Safety Business Agency to ensure they can comply with legislative requirements under the relevant Acts www.bluecard.qld.gov.au

- Filming and any other process by which a child could be identified will not be approved in any research application unless the following conditions are met:
    - That research participants and caregivers are fully informed regarding the intent, nature and scope of the research and that written consent is specifically given by the caregivers in relation to any filming/figurey/videoing etc. of participants
    - That the above condition also applies to research projects that involve longitudinal studies
    - That the researchers must provide details of the procedures they will use to ensure participant confidentiality – for example, strategies for information storage, access and disposal of data
    - That additional, written consent from the primary caregiver and research participants will be required, prior to utilising filming or any other participant identifying information, in any forum such as conference, teacher in-service, professional development, teaching instruction etc.

- Researchers are required to view the Diocese of Toowoomba Catholic Education *Volunteer Code of Conduct* and *Student Protection Information for Volunteers* documents, and complete a *Volunteer declaration form* prior to commencing any research in a school/schools. The Volunteer declaration form is to be submitted to the school Principal.

Anti-discrimination

- Researchers making application to conduct research in Diocese of Toowoomba Catholic Education schools are to ensure they can comply with legislative requirements under the Anti-discrimination Act 1991 (Qld).

Health Safety and Environment

- Researchers making application to conduct research in Diocese of Toowoomba Catholic Education schools are to ensure they can comply with legislative requirements under the Work, Health and Safety Act 2011 (Qld).

Form A

Research Proposal

(Please note: if applying for research as a part of an undergraduate or postgraduate course and the research does not require ethical clearance Form E must also be completed)

Principal researcher contact details	
Name	Alwyn Powell
Address	G426, Education Building, University Southern Queensland, Baker St, Toowoomba,
Tel	Work 0746312132 / Mobile 04
Em	Alwyn.powell@usq.edu.au

Supervisor/s' details	
Name	Professor Peter Albion
Address	L305 University of Southern Queensland, Baker Street, Toowoomba 4350
Tel	Work 0746 312321 / Mobile
Em	Peter.albion@usq.edu.au
Name	Dr Petrea Redmond
Address	G416, Education Building, University Southern Queensland, Baker St, Toowoomba,
Tel	Work 46312318 / Mobile
Em	Petrea.redmond@usq.edu.au

Overview of research	
Research project title	Identifying tools, materials and adhesive methods used in the primary school and factors influencing the opportunities to use them.

Brief overview of research project – including procedures and extent of student, teacher and

This research project will identify what tools, materials and adhesive methods teachers in primary schools are currently using in their classrooms, with the aim of developing a framework of use and leading to possible skills development of teachers. There is growing concern that the physical skills and coordination abilities of Australian children are not being effectively developed, including hand-eye, finger-eye, and wrist and arm movements. The ability of children to develop these skills into adulthood as part of a holistic education using skills for the twenty first century is useful for the concept of lifelong learning.

Skilled capability and competence in using tools, materials and adhesive methods is developed over time with increasingly complex tasks that involve instruction and practice. Though tools, materials and adhesive methods are mentioned across curriculum documents in Australia and Queensland, nowhere are they specifically named or identified as to when best to implement them, either by year level or curriculum area. Therefore, this initial investigative study is designed to identify what tools, materials and adhesive methods are currently being used within the primary school. It will also consider teacher and school dispositions towards using tools, materials and adhesive methods.

Therefore, this study will use a survey to identify what tools are currently being used and when, with a follow-up interview of teachers. Phase one will be a survey of approximately 120 teachers across all primary school year levels in both Catholic and State systems, followed by phase two interviews with six to twelve teachers. A sample of the draft survey is included as an appendix along with a sample of draft questions for the interview stage. These questions will most likely be modified by the results of phase one. The compilation and analysis of data in phase three will provide the basis of the framework.

Only Teachers will be asked to complete survey for this research, which will require about fifteen minutes.

Brief description of benefits of the research to the participants eg how teachers and students will benefit from

This research project will identify what tools, materials and adhesive methods teachers in primary schools are currently using in their classrooms, with the aim of developing a framework of use and leading to possible skills development of teachers. There is growing concern that the physical skills and coordination abilities of Australian children are not being effectively developed, including hand-eye, finger-eye, and wrist and arm movements. The ability of children to develop these skills into adulthood as part of a holistic education using skills for the twenty first century is useful for the concept of lifelong learning.

Skilled capability and competence in using tools, materials and adhesive methods is developed over time with increasingly complex tasks that involve instruction and practice. Though tools, materials and adhesive methods are mentioned across curriculum documents in Australia and Queensland, nowhere are they specifically

Brief description of the research design and methodology and any strategies to be employed to ensure

A mixed method research design (Creswell, 2012; Wiersma, 2005) is planned, with quantitative dominance (Johnson, Onwuegbuzie, & Turner, 2007). The study will comprise three phases based on Creswell's (2009) Sequential Exploratory Design. The sections of Sequential Exploratory Design are; Phase one survey, Phase two interview, and Phase three data analysis Interpretation of entire study.

Phase one of the study has participant teachers from State and Catholic primary schools in Southern Queensland. Schools will be directly approached through the principal, to participate. The Responses from over 120 teachers across the seven years of primary school will be collated in groupings of teachers from prep to year two, years three and four, and years five and six. These will allow for many small school amalgamated classes as well as aligning with the Australian Curriculum stages. There will be a minimum of forty teachers in each year level grouping. Schools will be contacted directly by researcher and all surveys which are hard copy paper, will be hand delivered and collected by the researcher, within a blank envelope. The survey will not be on-line.

Follow-up interviews from a small sample will be conducted after survey and before end semester one 2016. Concurrent short qualitative open ended questions will allow teachers to highlight enabling ways they use tools and materials and to identify perceived issues relating to such issues as access to tools, safety, materials, adhesive methods, storage and professional development. To ensure the feasibility of questions and format it is planned to perform a pilot test of the questions with a small local school.

In phase 2 a small sample of teachers will be interviewed with regards to specific questions that are identified from phase one. The follow-up face to face interview based on the findings of phase one will encompass semi-structured questions with a small number of teachers. These will provide a more in-depth consideration of enabling and inhibiting practices that teachers engage with. Teachers from schools visited during phase one will be invited to indicate their willingness to participate in the interview process. The selection of teachers will reflect a range of year levels across the primary school. Coding (for example, Teacher A) will be

Approval to participate processes to be implemented including examples of permission letters/consent forms

See attached

Details of procedures for establishing confidentiality and protecting privacy including information management

- Anonymous survey
- Single form.
- Personalised delivery and collection, to put a face to the project, for safe keeping of data and to answer questions.
- Choosing a common time if available such as a staff meeting.
- Social stresses from within workplaces will be minimised by the anonymity of data and the large number of teachers involved, and all the Responses will be returned in blank envelopes. Also the personal approach of researcher in the delivery and collection of data will ease concerns through immediate collection of sealed envelopes and being able to respond to questions immediately.
- Digital recordings will be stored in password protected files on USQ systems.
- No names on digital audio recording files rather they will be codified.
- Data only accessed in organised collated form

List school name/s and addresses and the groups that will be requested to participate in the

Research comme	November 2015	Res earch	July 2017

Documentation checklist	
	Ethical clearance from University Ethics Committee
	Copies of data collection and survey instruments
	Copies of participation consent letters and forms
	Copy of the letter to Principal/s of school/s who will be approached
	A copy of your Working with Children Suitability Card (Blue Card) or evidence that a

Principal researcher name	Alwyn Powell	Signature	
Supervisor name	Peter Albion	Signature	

Form B

Diocese of Toowoomba
CATHOLIC EDUCATION

Confidentiality declaration by Principal Researcher

1. I am aware of and will comply with the special responsibilities associated with undertaking research with children and young people, specifically, my responsibilities and obligations under the *insert name of appropriate Child Protection Legislation here* and the *Privacy Act 1988 (Cth).*

2. I declare that there are no other circumstances or reasons that might preclude my undertaking research with children and young people.

3. In relation to assistants conducting research with children and young people either with me and /or on my behalf, I will ensure that:

   a. They are made aware of the special responsibilities associated with undertaking research with children and young people, specifically, their responsibilities and obligations under the *insert name of appropriate Child Protection Legislation here* and the *Privacy Act 1988* (Cth). (See **Form C** for assistant researchers)

4. I have provided as part of my submission a copy of my suitability card or evidence that a working with children suitability card is not required.

……………………………………. ……………October 2015.

Signature of principal researcher Date

Form C

Confidentiality declaration by Assistant Researcher

1. I am aware of and will comply with the special responsibilities associated with undertaking research with children and young people, specifically, my responsibilities and obligations under the *insert name of appropriate Child Protection Legislation here* and the *Privacy Act 1988 (Cth).*

2. I declare that there are no other circumstances or reasons that might preclude my undertaking research with children and young people.

3. I have provided as part of my submission a copy of my suitability card or evidence that a working with children suitability card is not required.

……………………………………. …………………………

Signature of assistant researcher Date

Form D

Agreement to provide research findings to Diocese of Toowoomba Catholic Education Office

As Principal Researcher:

1. I agree to provide Diocese of Toowoomba Catholic Education Office with a copy of the research findings published or unpublished of the proposed study upon completion.

2. I grant Diocese of Toowoomba Catholic Education Office the right to disseminate this report to employees of the Diocese of Toowoomba Catholic Education Office.

3. I agree to provide the participating school/s with a summary of the research findings published or unpublished.

4. I understand that, if Diocese of Toowoomba Catholic Education Office wishes to disseminate the report more widely, this will be done in consultation with me.

………………………………….. ……30 October 2015……

Signature of Principal Researcher Date

Form E

Diocese of Toowoomba
CATHOLIC EDUCATION

Research Approval

for undergraduate and postgraduate students

This approval is to be completed by the researcher and the supervisor in cases where the research does not require ethical approval from the Universities' Ethics committee.

Principal researcher contact details		
Name		
Address		
Tel	Work	Mobile
Em		

Supervisor/s' details		
Name		
Address		
Tel	Work	Mobile
Em		
Name		
Address		
Tel	Work	Mobile
Em		

Overview of research – please comment on the following aspects of your student's research	
Title of	
Significance, purpose and value of the research (include a copy of the assessment criteria for the unit of	
Appropriateness of their research design (include a copy of data collection instruments and	
Adequacy and viability of their proposed methodology	

Ethical considerations and how these are being addressed including examples of permission letters/consent form			
Capability of Principal Researcher			
Is ethical approval required for this		☐ Yes ☐ No	
Supervisor name		Signatur	

13.4 Appendix 4 Sample of data base

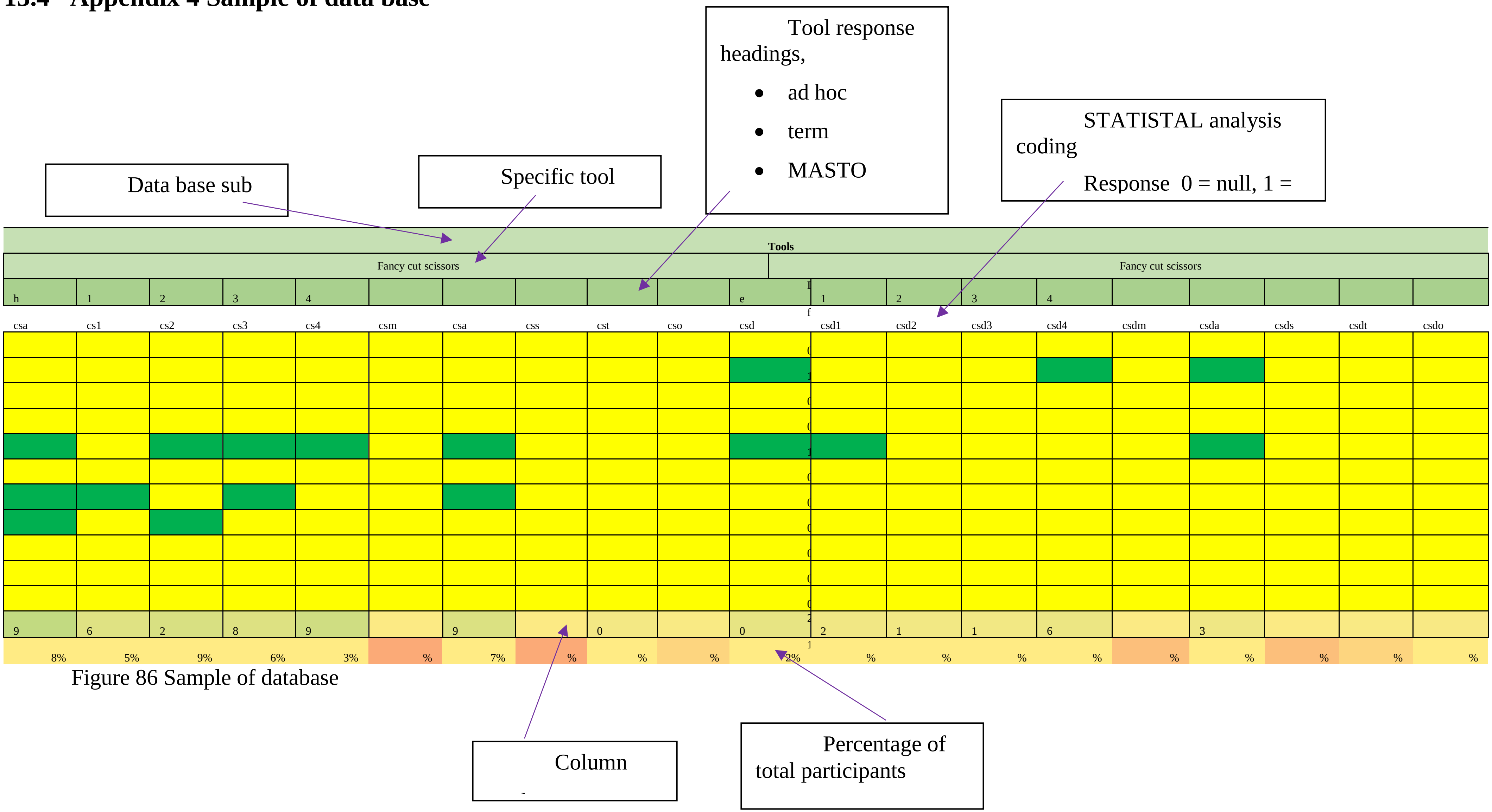

Figure 86 Sample of database

13.5 Appendix 5 Draft School audit document

Year level		Quantity	term 1	term 2	term 3	term 4	specific skill taught
knives	plastic						
metal	Butter						
	Stanley						
	box/ razor						
	Scalpel						
	Bread						
scissors	blunt nose						
	fancy cut						
	shears - card						
	pinking shears						
saws	Tenon						
	Hand						
	Fret						
	Hack						
	electric scroll						
	electric jigsaw						
cutters	Guillotine						
	rotary cutter						
	strip cutter						
	Circular						
	Metal						
pliers	snub nose						
	Longnose						
	Pinchers						
	side cutters						
	wire strippers						
	locking pliers						
spanners	open ended						
	box wrench						
	adjustable						
	socket wrench						
	Allen key						
vice	table vice						
	g clamp						
	screw clamp						
punches	single hole						
	double hole						
	multi hole						
	fancy						
smoothing	Sandpaper						
	Files						
	rasp files						

Year level		Quantity	term 1	term 2	term 3	term 4	specific skill taught
hammers	Tack						
	Claw						
	Ball						
drivers	flat blade						
	Philips						
	Hex						
drills	Hand						
	Brace						
	battery operated						
	electric						
maths tools	Ruler						
	Compass						
	set square						
	measuring scale						
	tape measure						
	Protractor						
	3 D printer						
	badge maker						
	Laser etcher						
handwriting							
	Pencil						
	Crayon						
	Chalk						
	pen						
	felt markers						
paper							
	Tissue						
	Photocopy						
	Cartridge						
	photocopy card						
	straw board						
	Corrugated						
	Tubes						
plastic	Straws						
	Cellophane						
	cling film						
	library plastic						
	rubbish bags						
	flute board						
	Straws						

Year level		Quantity	term 1	term 2	term 3	term 4	specific skill taught
	Hessian						
	Calico						
	Canvas						
	polyester cotton						
man-made	faux fur						
	Nylon						
	Rayon						
wood	Sheet						
	Matchsticks						
	Skewers						
	paddle pop						
	Balsa						
	laminated wood						
	MDF						
	Pine						
	Hardwood						
metal	Dowel						
	Single core wire						
	aluminium foil						
	copper foil						
	Tin						
other	multi -strand wire						
	Clay						
	Glass						
	Perspex						
	corrugated card						
adhesive	glue gun						
	knitting needle						
	plier stapler						
	staple gun						
glue	desk stapler						
	flour and water						
	glue stick						
	Clag						
	Gum						
	PVA / wood						
	Acetate						
	Plastic						
	hot glue						
	Superglue						

Year level		Quantity	term 1	term 2	term 3	term 4	specific skill taught
thread	needle and cotton						
	knitting wool						
	leather thong						
	fishing line						
	sewing machine						
	String						
	ties plastic						
	ties wire						
	cotton thick						
metal	Twine						
	Rivets						
	Tacks						
	Nails						
	Screws						
	soldering iron						
	solder						
adhesive tape	Wire						
	pipe cleaners						
	Staple						
	cello tape						
	masking tape						
	material tape						
	electrical tape						
	laminating machine						
colour	Charcoal						
	Ochre						
	coloured pencils						
	water colour pencils						
	water colour paint						
	acrylic paint						
	oil paint						
	house paint						
	Varnish						
	Inks						
	material dyes						
	Felt pens						