Aligning Mapping Skills With Digitally Connected Childhoods to Advance the Development of Spatial Cognition and Ways of Thinking in Primary School Geography

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Abstract

New technologies are changing the ways that children navigate, find places, make and use maps, and explore the world. This is the geospatial revolution. Children live in a world of rapid technological innovation bringing new opportunities for cognitive development in school geography. Geography learning is an important component of primary school curriculum in Australia and internationally. However how young people's mapping skills can be developed in a digitally connected realm has become an important question. These technologies require us to rethink the teaching of mapping skills in primary schools, both to take advantage of technology, and to connect with children who are growing up in a digital age. We argue that mapping in the curriculum is much more about developing spatial thinking skills by building spatial concepts. Given these purposes for learning about maps and mapping skills, teaching in primary schools can enhance students' knowledge of geography and spatial skills through a focus on the spatial concepts and ways of thinking. This article synthesises what is known about the purposes of mapping skills, spatial cognition and geography education, and how children learn mapping. It argues that teachers can use the new technologies to do this as well as established approaches. It then applies these to proposing how established methods can be augmented by innovative approaches to building spatial thinking skills.

Introduction and the world of now

Post-millennial childhood heralds a new era in opportunities for cognitive development. The e-World package of internet linked personal devices opens the world of experience to infinite choices and decisions (Castree, 2016). Geo-tagging of places and spaces linked with daily activities effectively changes how children directly engage with real time space and place. The App library acts as a filter for where to go and presents options for how to get there. Added to this process, the symbols of traditional maps are no longer needed. Voice recognition provides the medium of translation between the device finder and the user. The consequence is that the ground covered may be incidental in the overall experience for the young device operator. In an attempt to grasp the significance of these societal changes in the post-millennial childhood experience we make an effort to show links between behaviours now and the more traditional signposts of mapping, map making and mapping comprehension (see Downs & Stea, 2017). Youngsters of the post-millennial age may not get too enthusiastic about venturing too far from 'civilisation', or being out of range for their mobile devices, but, arguably, they are 'seeing' the wonders of the world in other ways that are not well understood or researched (Robertson, Montouro, & Burston, 2019).

First, there was geocaching. Then there was Pokémon Go. Augmented reality captures the imagination in ways that hiking through the bush to locate caches may not. However, interestingly, the combination of reality-based mobility and virtual characters has also lost some favour from its initial popularity. Like osmosis the magic of running around the neighbourhood to catch Pokémons drifted from continent to continent and now though it's not newsworthy it is still played by millions of people. The phenomenon is fascinating as it blends cognitive mapping skills, associated spatial navigational behaviours and fantasy (Žižek, 2008). The iPhone generation (iGen) rely on their phones for social, emotional and information needs (Twenge, 2018). The implications of these behaviours for understanding the cognitive processes of young learners is a new field for researchers and educators. New questions are the result in the world of now: How do educators capture these children's imaginations to ensure that the learning challenges are meaningful – for the child? Curriculums are interpretative statements of a nation's educational needs, and geography educators have defined core concepts that lend themselves to meaningful application in a geospatial-technology enriched world. Improving understanding of the spatial cognition of the iGen children can be the benchmark for relevance, authenticity in learning tasks, and sustainable learning.

The point is that the knowledge affordances of the world of now (Harvey 2016; Robertson 2008; Virilio, 2000), including geospatial technologies, are embedded in mainstream culture. This is well captured by Downs (2014) who summarises the likely impact on humans and the institutions that support our lifestyles as being two-fold.

> The geospatial revolution has two human implications. First, as knowing actors, people make choices based on the analysis and presentation of geospatial data. Second, as known subjects, people's choices become data as their behavior is monitored through real-time tracking. . . . Both of these human implications affect the geographic sense of self: what is known about the world, how people see themselves in relation to it, and how people behave spatially in it. (Downs 2014 p. 36)

Inextricably linked with the changes afforded by the geospatial revolution is the sense of geographic self or inner space, which in turn has deep implications for geographical education and how children acquire spatial knowledge and understandings. For geographical education the possibilities of linking the digital and real worlds seem infinite. Geospatial tools align content, processes and learning outcomes in ways that ought to excite learners and endure in their cognitive and spatial development. Preparation for their worlds, including their sense of self, are part of their identity formation. Our challenges in geographical education are to herald the changes and embrace them in our pedagogical practices. For instance, as a classroom tool for modelling landscapes and altering patterns associated with real space how cool is 4D cartography? Using 3D representations with time added as a fourth dimension making possible new visualisations. (Resch, Hillen, Reimer & Spitzer, 2013). As the inherently geographic way of connecting space and place relations, how we teach mapping skills has the potential to harness the best of new and emerging technologies. There is a *mapping (cultural) turn* in everyday life that needs explication and interpretation for meaning making and knowledge creation.

Our goal in this article is to contribute to a better understanding of the geospatial revolution and the tools that are commonly used by geographers. The sections that follow include an overview of the existing literature and curriculum innovations that appear to best illustrate the new wave of geographical education thought including how best to equip students to design real-world plans (see for example, Harvey & Kotting, 2011). Following this we include examples of best practice and applied action specific to mapping skills and their acquisition.

The starting points: linking the geospatial revolution with primary school education

For the post-millennials innovative practice in primary schools starts with the geospatial revolution. Geospatial technologies refer to a vast array of increasingly sophisticated tools that are capable of capturing and manipulating spatial data. The growing availability of these digital databases and their interoperability makes them accessible for teachers. They 'fit' the criteria for contemporary childhood experiences. Coded by location, the technologies both capture the data, and turn them into maps and other locational information. Primary school students can access this information through software such as Google Maps, Google Earth, online mapping programs and electronic atlases, using tablets and computers. They are observing their family's use of smart phones and other devices from an early age. The use of these technological devices by school students is widespread by early-secondary school age. For example, a 2016 Australian Roy Morgan survey found that 11% of 9 year-olds, 27% of 11 year-olds and 66% of 13 year-olds have a mobile phone (Roy Morgan Research, 2016). A 2017 Australian Child Health Poll found that 36% of 3–5 year-olds, 67% of 6–12 year-olds, and 94% of 13–17 year-olds owned a smartphone and/or tablet (Australian Child Health Poll, 2017).

Children's access to geospatial technologies means they no longer need printed maps to find places. Students can access up-to-date written and visual information about places throughout the world, and take virtual tours through many of them. "The scale of the familiar world, the depth and accuracy of knowledge of that world, and the command and comfort within it will change [have changed] dramatically" (Downs 2016, p. 48). As a consequence:

> Skills in searching for [geographic] information, part of procedural knowledge, may replace much of the base of declarative knowledge, placing a premium on knowing how and where to find geospatial information rather than memorizing that information. (Downs 2016, p. 48)

Downs also describes how the geospatial revolution provides new and more flexible ways to navigate from one place to another, with routes selected according to criteria specified by the user. These routes might be the shortest, the quickest, the most scenic and so on. He writes: "There is a potential diffusion of geographic knowledge and mapping skills to many people. There is the possibility of security and adventurousness in behaviour" (Downs 2016, p. 49). Similarly, the availability of simple online mapping programs may make teaching students to draw maps by hand an obsolete and unnecessary task.

On the other hand, there are some potential negative consequences of the geospatial revolution. One relates to people's dependency on technology. Downs (2014, pp. 53–54) concludes:

> For members of Generation M [now iGen], access to and participation in the virtual geographic world is rapidly becoming the norm. The tools and technology foster dependency. . . . Maps can contain errors from data bases that are incorrect or out-of-date. Network coverage is geographically variable in quality: . . . Tools break and malfunction. Batteries die and electrical power fails. Phones can be lost or stolen. Internet connections can be hacked. How do we establish a balance between utility and dependence, between reliance and vulnerability?

A second consequence of dependence on geospatial technology is that it results in people having limited geographical information stored in the memory. However, it is difficult to think about the world if one has no mental map of it, and of the relative location of places and countries. It is also inefficient to have to use a smartphone for every fact, so some declarative knowledge is still needed.

A third consequence relates to cognition:

> There is emerging evidence that on-line software is beginning to have an effect on cognition. Sparrow, Liu, and Wegner [2011], for example, showed that access to on-line search engines affects both memory for and strategies of searching for information. . . . For example, does the use of GPS-based direction software, with its focus on point-to-point routes, diminish the likelihood of children forming coherent and integrated cognitive maps of their neighborhoods? Does route-tracking distract children from looking at the world around them? Does the sense of security offered by GPS software lead to adventurous behavior that puts children at additional and dysfunctional risk? (Downs 2014, p. 53)

A related cognitive issue is about the effects of a dependence on GPS technology on the brain. Studies suggest that people who navigate by building a cognitive map showing the relationships between landmarks have a larger hippocampus, which involves spatial thinking, than those who navigate by learning or following a path, which does not. The significance of this is that a larger hippocampus may reduce the risk of dementia and Alzheimer's in old age (Konishi et al. 2017). This is an insufficiently researched problem, but it may need to be taken seriously. In brief, there are both advantages and disadvantages in the growing reliance on geospatial technologies.

Purposes of mapping skills, spatial cognition and geographical education

The bridge between the cognitive impact and learning experiences is the challenge for geographical education. Given that the geospatial revolution is now well established, and today's students will enter a world in which more and more information is locationally coded, and more and more software and applications are available to access and use this information, raises the question of what are the purposes of teaching mapping skills? Five purposes are suggested.

1. Children should learn how to access, evaluate and use geospatial information on their phones, tablets and computers, in the same way that they learn how to evaluate and use information on the web. As Gauvain argues:

   > In the unrelenting information stream which we live in today, it will be important to help children understand how and when to be circumspect about the information they obtain from geospatial technologies, how to check and evaluate the source, and how to monitor their progress in case the

> information is wrong or not helpful. (Gauvain, 2014, p. 61)

Part of this process is also learning about the potential dangers of revealing their own location to others through their smartphones.

2. Maps help to develop young children's knowledge of their own locality and its surroundings, which is important both for their safety and the development of their sense of belonging.
3. As students progress through primary school maps help them find out where their place is located in the world. They discover other places and develop the locational knowledge of the world needed to interpret and understand events. Some of this knowledge can be obtained from electronic sources but understanding will be enriched through the use of a globe to accurately understand the relative locations of places.
4. Maps are central to learning to think geographically. Maps are a way that geographers describe places, portray locations and spatial distributions, and analyse information. In particular, they develop the ability to visualise the world spatially, and to see patterns and relationships, and these are valuable skills. This means that students should learn how to use and interpret a variety of maps, including those they are likely to encounter in digital media. Added to this interpretive knowledge, learning how to construct them for themselves can add to their geographical understanding, and this construction can be done digitally by primary school children using appropriate software. Bridge writes:

   > Maps have the power to turn the abstract ideas, which we form in our heads, into visual reality. Only a handful of people will ever actually see the UK complete from space. Even fewer can expect to see the whole world in one go except as a map. Maps and plans have a potential for radically extending our understanding by portraying the layout and organisation of the school, revealing the network of roads in a town or region or showing the distribution of natural vegetation such as forests and grasslands. Maps contextualise information within defined spatial boundaries, allowing us to make comparisons, formulate plans and develop generalisations. The identification and analysis of patterns, processes and relationships stands at the heart of geography. (Bridge, 2010, p. 116)

5. Learning to make, interpret and use maps helps to develop children's spatial intelligence. It is now well established that this is a separate type of intelligence, additional to mathematical intelligence and verbal intelligence (Ness, Farenga & Garofalo, 2017). Spatial intelligence, or the ability to think spatially, is important in everyday life, but is also used in mathematics, several fields of science, architecture, engineering, urban planning and geography. Skill in spatial thinking is positively correlated with competence in mathematics and some branches of science (Newcombe, 2010, 2017), although the reasons for this relationship are not yet fully understood (Mix, 2019). There is also some evidence that training to increase spatial skills, from preschool onwards, improves learning in STEM subjects (Newcombe, 2017). Geography has a significant role to play in this training, as Liben (2017, p. 221) argues that 'geography education in general, and map education in particular, can have an important place in developing spatial thinkers'.

   Mapping is therefore much more about developing spatial thinking skills than learning how to find places and navigate from one place to another. Spatial thinking is defined as:

   > the use of spatial concepts, spatial representations, and processes of reasoning to conceptualize and solve problems. Following this definition, spatial thinking involves the ability to visualize and interpret data about space that is then encoded and stored in memory. This definition emphasizes language (knowing and using spatial concepts such as location, distance, scale); being able to understand spatial representations such as maps, graphics, and diagrams; and the application of these to problem solving, both personal and academic. This is related to the development of a *spatial habit of mind.* This is the predilection to think spatially and to apply the skills required to engage in reasoning with concepts of space and visual representations. (Bednarz, 2018, p. 3)

One aspect of this spatial thinking has been described as survey knowledge — the ability to think about multiple relations among locations based on the information provided by an aerial photograph or map. Research shows that 4-year-old children can acquire survey-like information from aerial photographs and maps (Robertson & Taplin 2002). As Davies and Uttal argue (2007), maps facilitate children's thinking about spatial relations.

> Maps can become 'tools for thought', allowing children to encode spatial relations in an efficient, integrated manner that is difficult, and sometimes impossible, to gain from direct experience or from linguistic descriptions. (p. 233).

On the other hand, electronic navigation programs, which provide only point to point information (and which may be verbal rather than visual), may fail to develop this ability to perceive spatial relations and think spatially. This is because when children are following a designated route, they are not observing the space through which this route passes, or the relative location of places within this space, and they are not developing cognitive maps of places.

Given these purposes for learning about maps and mapping skills, teaching in primary schools can enhance students' knowledge of geography and spatial skills through a focus on the following spatial concepts and ways of thinking.

- **Identity and location:** Students should learn to find places, features and landmarks on maps and aerial photos, starting with familiar places and progressing to maps of unfamiliar places. The maps should be both printed and digital, and students should learn how to read them, and how to identify their limitations, such as what they don't show.
- **Distance and direction:** Students should progress from topological concepts of distance (such as near, far, next to) to different metric measurements of distance (such as straight line kilometres, road route kilometres, travel time, travel cost), and from simple directions (such as straight, left, right) to directions by cardinal points and degrees. They should learn how to use printed and digital maps to navigate, and the limitations of different methods.
- **Relative location:** This is the location of a feature or place relative to the locations of other features or places, and includes the concepts of proximity, centrality and remoteness. Relative location often has more influence than absolute location.
- **Scale:** Students should learn how scale is used to construct and interpret maps.
- **Symbols:** Students should progress from pictorial symbols on maps to abstract icons. The use of symbols to represent things is not restricted to maps, so an understanding of symbols is a useful skill.
- **Reference frames:** Students should progress from simple alphanumeric grids to numerical grid references and latitude and longitude. The concept of using a grid to locate something in space is an important skill, and the emergency services use GPS coordinates for latitude and longitude to locate emergencies. Australia's Triple Zero Awareness Working Group has developed a smartphone app for iOS, Android and Windows devices, which displays the GPS coordinates of a phone's location that a caller can read out to the emergency operator. It is therefore important that students learn what these coordinates mean.
- **Hierarchies:** Students should learn the concept of a spatially nested hierarchy (such as their address) in which each place is located inside a larger place, a feature sometimes compared with a Russian doll. This can be a difficult concept for young children.
- **Spatial distributions and spatial patterns:** Students should learn to interpret maps showing the spatial distribution of a wide range of categorical and numerical information, and to perceive regularities or patterns in these distributions. They should understand how spatial distributions have environmental, social, economic or political outcomes, such as the effect of the distribution of rainfall on both the type of vegetation and the density of population. Students should also understand how spatial distributions can be used to develop ideas about causation. For example, a simple map of the location of activities in the local area could be used to stimulate thinking about why they are located where they are. Similarly, a world map of the distribution of average life expectancy by country could be used to stimulate thinking about what causes these differences in health outcomes.
- **Spatial association:** Students should learn that similarities in the spatial distribution of two variables could indicate a causal relationship between them. For example, in searching for the causes of differences in life expectancy, students might look at maps of national per capita income or educational attainment to see if they are similar.
- **Map projections:** Students should learn that different map projections portray the surface of the earth in very different ways, and influence the way that we perceive the world and the relative size of countries. The Mercator projection, which exaggerates the size of temperate and polar regions and diminishes the size of tropical regions, is gradually disappearing, but gives a highly misleading picture of the relative areal size of countries.

For example, it portrays Australia as much smaller than Greenland, when in reality it is several times larger.

The aim in all these concepts is to use the teaching of technical skills in map making and map interpretation in concert with rich geographical inquiries to develop breadth and depth in understanding of spatial concepts and spatial thinking.

What is known about children's map learning?

There has been a considerable amount of research into children's abilities to understand and use maps, and into the difficulties they may experience in interpreting them. Bednarz, Acheson, and Bednarz (2006) have reviewed much of this research and identified some important findings. The first is that children as young as three and four (see also Robertson & Taplin, 2002; Uttal, 2018) are able to interpret maps and remotely sensed images (such as aerial photographs and satellite images), especially of familiar places, and to use them to find locations and trace routes between them. They can also interpret simple maps and perceive patterns represented in them by colours or shading, without any formal instruction. This supports the argument advanced by some researchers that the mapping abilities of young children are innate, and have evolved in most cultures because of the need for children to understand their surroundings in a map-like way for their survival. There is therefore no reason to delay introducing young children to maps and vertical images.

However, this ability to understand spatial representations at early ages is limited to small spaces, those with which children are familiar, and does not automatically transfer to larger spaces, such as regions or countries, that are beyond a child's experience (Uttal, 2018). Without formal instruction, students do not progress further in their mapping skills than this initial stage. Research has shown that students can have difficulty correctly interpreting a number of features of maps, including:

- The use of colours to show climate or vegetation zones, different states or territories, relief (height above sea level) and other characteristics of areas, For example, they may fail to understand that the colour on a map may not correspond with the colour of what is being represented.
- The use of symbols that show roads, the location of towns, the population of cities, economic activities, and other features. For example, they may fail to understand that a dot represents the location of a place and not its size.
- The relationship between two spatial distributions when high values on one distribution are associated with low values on the other.

The formal teaching of mapping and map interpretation is therefore essential throughout the primary school years. As research reviewed by Weigand (2006) confirms, the learning progression for drawing maps proceeds from pictorial maps through plans to large-scale and then small-scale maps. Pictorial maps portray the features of places by pictures of buildings, roads and rivers, while plans are more abstract maps of small areas, such as the child's school. Large-scale maps are maps of a small area, such as a neighbourhood or suburb, because the scale is a relatively large ratio. Small-scale maps show a large area, like the whole of a state or country. Large-scale maps are taught first because they are about areas that students are familiar with, and this is how they learn to relate a map to the real world it portrays. Suggestions on how to sequence map teaching and learning with pre-school and primary school children can be found in Catling (2018).

The question remaining from this overview is how to marry what is known about the development of spatial cognition and mapping skills with new affordances of geospatial technologies in the day to day practices of classroom teaching.

Building spatial cognition through known places

Opportunities to learn about space will occur naturally though life experiences which vary from child to child (Liben & Christensen, 2010). Primary geography has an essential role to play in providing opportunities for children to interact with the environment to master interpreting graphical representations of places. Children benefit from opportunities to develop their spatial cognition by visiting places. In the early years of education, these places are likely to be their school, their school's local area, their home, back yard (if they have one) and other places in their local area. These are places that they readily visit or can easily visit. In essence, they are known three-dimensional spaces. Places are destinations. The act of wayfinding to various places is also important to developing spatial cognition as it can build knowledge of scale and distance. School programs can offer systematic studies of places that enable all young people to develop beyond the incidental progress that they will make. As highlighted in the previous section the research shows that being in space, and connecting with the features of places is founded on some fundamental tenets. First, constructing spatial knowledge begins with being in space, which can then be harnessed by teaching children to recognise representations of these places – most commonly through maps, and less commonly via three dimensional models. As interactions with environments will not, by themselves, guarantee advanced levels of spatial cognition, a second tenet is that children develop mapping skills by using online and print maps or plans of *known* places and making or illustrating features on maps or plans of *known* places. Research has demonstrated that spatial cognition is more developed in children who are actively visiting and using representations of places they visited (see, for example, Wiegand, 2006). What studies show is that children who walk to school draw more accurate and more detailed maps than those who are driven, unless the adults doing the driving talk about the route they are taking. Studies also show that children who are allowed to actively explore their neighbourhood have better spatial skills, like route-finding and remembering places, than children whose mobility is constrained (Risotto & Giuliani, 2006). Four- and five-year-olds can comprehend and interpret aerial photographs as representations of the real world, and can use them to find locations in the real world (Plester, Blades, & Spencer, 2003). The same researchers also suggest that experiencing an aerial photograph of a place makes it easier for children to understand a map of the same place, leading to the conclusion that 'young children would benefit from working with aerial photographs before they start working with maps' (Plester, Blades, & Spencer, 2003, p. 292). Initially the images must be of familiar spaces that children use daily – such as the school, the immediate neighbourhood of their home, or the local shopping area – so that they can relate what they see in the image to what they know is there on the ground. Importantly, this tenet links to questions about how to gather, and what tools to use for the process of gathering data in the field: Digital processes versus traditional methods of recording data on spreadsheets and print maps for the task? Finally, a third tenet is that children also learn by examining maps of places they *will* visit and then testing their understanding of them by visiting that place. In school settings this often occurs associated with excursions, fieldtrips and school camps.

Each of these ideas sits alongside geospatial technology applications which can be alternative pathways to both enable and enhance the teaching of spatial learning. Children can take a field-walk to their local park and back in class study aerial photographs of that area using Google Earth. They ask questions: When was the image taken? Who was using the park then? Have features in the park changed? They can return to the park to map usage by drawing dots of people on a map of the area that they have printed from Google Maps. Or they might develop a questionnaire and use a georeferenced application such as ESRI's Survey123 to input data about users so they can produce a computer-generated map of users in the park. In this example, modern applications can be used as a more effective way to learn, a more motivating way to learn and sometimes they are a profoundly new way to enhance learning.

One way that spatial cognition is developed in school curricula is through projects in which students map features of their classroom, school grounds or local area. This is not new. However, the approaches being fostered for the Australian curriculum in primary education are being enhanced by the availability of digital applications for both recording of spatial data and the need to take transdisciplinary approaches. STEM curricula (cross-curriculum teaching of Science, Technology, Engineering and Mathematics) and associated state and federal government funding intiatives are providing impetus for schools to augment the professional development of teachers in ways that develop skills within real world contexts. That translates to new approaches from established teaching methods to consider and implement innovative practices more likely to mirror real life. Technological advances now provide what was once-astonishing information about places through GIS, satellite imagery, aerial photos and animations. Teachers have bountiful opportunities to draw on programs including Google Earth and virtual realities that simulate three-dimensional space, and to use these in concert with the child's environment. The use of GIS to solve problems can also be introduced in upper primary school, and has been shown to stimulate student interest. (Jadallah et al., 2017). Children enjoy using GPS to undertake treasure hunts in geocaching in their local area and it can advance their spatial cognition (Conlan, 2017). Children develop their skills over time and experience to improve spatial competencies. They become more capable spatial thinkers through curricula that incorporate activities in places that use maps of these places, and by making and using representations of known *and* unknown places.

Promoting spatial learning in this cross-curricula manner requires teacher confidence to 'see' the possibilities. In forward-looking primary classrooms, the teachers' role in this process depends on their personal skill capabilities with the new technologies as well as their discipline knowledge. Considering an example of practice can enable both an evaluation of existing practice and identifying ways for improvement to better match the future worlds of learners. What follows

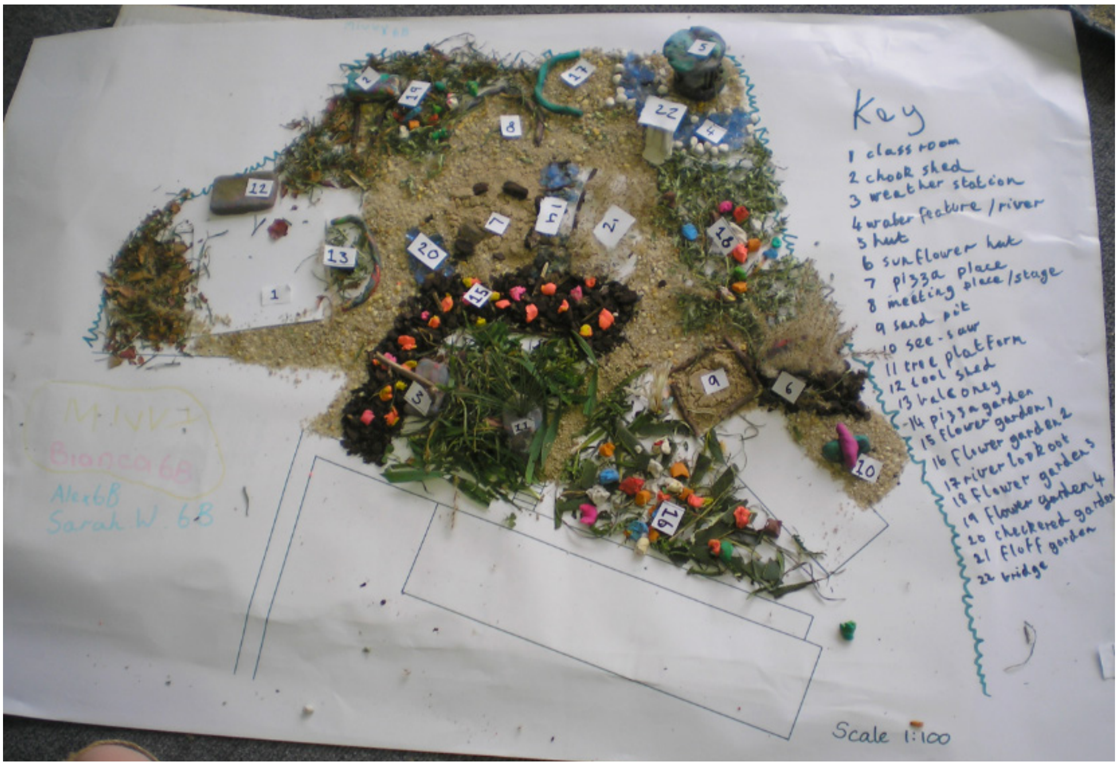

Figure 1: Grade 6 group's finished model of the development of an area adjacent to the school featuring a 'pizza garden' in which the children grow herb toppings for the pizza oven

Figure 2: Grade 5 group's model includes a chicken's drinking pond, maze, gazebo and composting area.

is a case study of a landscape project conducted in a local primary school.

Case study: Designing a learning landscape at The Patch Primary School

At The Patch Primary School, 45 Kilometres east of the Australian city of Melbourne, school students worked with the school community to design a use for a disused area adjacent to the school. Called a learning landscape, this project had outcomes in a range of curriculum areas including geography, mathematics, science and art. The design process included phases of investigating, consulting, collaborating, designing and communicating (Rayner, 2017).

Specifically this project developed spatial cognition when students estimated and calculated distance and area, located specific features and developed scale drawings and models (see Figures 1 and 2). Mapping skills are implicit as the detail indicates. There are symbols, a key, spatial representation distinguished by colour, patterns and arrangement. Three dimensional, the representation indicates the learners' efforts to model real space and the impact of vertical structures on shade options.

The process has much to commend it in the context of contemporary curriculum thinking. In this project comparing representations on plans and Google Earth aerial views can provide a link to the power of digital representation. Distance can be measured in Google Maps as well as at the site to discuss which is more accurate, and why. There are interesting applications to considering their local site to ground truth with other digital and paper representations so that students understand that Google Maps relies on images taken in the past, and that it may not show exactly what they see.

This project is then a platform on which, in the following years, geography lessons can develop using new technologies. For instance, field data are gathered and logged via digital waypoints using mobile phones, and new aerial footage is collected using drones. The options are becoming increasingly affordable and available for schools. Once the waypoints are collected, mapping applications can be used to convert the data to digitised maps using readily available applications from ESRI sources (see for example, ArcGIS). Once in digital format the mapping options can create new possibilities for discussion, planning and implementing change (see Appendix 1 for lists commonly used mapping tools). With additional access to a 3D printer these landscape features could be constructed as a three-dimensional terrain model.

The point of this development in learning options is to bring the real world of geospatial technologies to the forefront of educational thinking. Twenty-first century classrooms for the post-millennials need to match the lived experience of what is now everyday practices in the community. Learners need to go through the process of recognising and implementing their own meaning making using the steps of established pedagogical approaches to geographical education, as well as embracing the affordances of new technologies. The skills developed in the The Patch example remain fundamental for learners to grasp the meaning of maps and map making. Digital technologies can enhance geographical understanding and spatial cognition, but we need to be cautious that learning progression will be be developed when children recognise and implement their own meaning making using models, local fieldwork and by examining aerial photos (Plester, Blades, & Spencer, 2003). Then, embracing geospatial technologies in the world of now can enrich their spatial cognition, develop industry-valued skills and engage learners.

Conclusion

There is an old adage "once a learner, always a learner". For adult professionals who have the responsibility of teaching the post-millennials this seems an apt mantra. The constancy of change with the globalised world of knowledge, and its availability via personal digital devices is revolutionary for human endeavour. Preparing children to succeed within the parameters of this new world paradigm places a significant burden on teachers, parents and teacher educators to support and guide their development (Kriewaldt & Hutchinson, 2010). Knowing how to map and how to use maps is part of everyday life. Spatial cognition of the real world comes with child development. The real challenges are twofold. The first is how to harness this inherent knowing in ways that help the knower to make the most of the geospatial tools available now to better understand mapping and maps. The second is how to help the knower develop an understanding of spatial concepts and their ability to think spatially. Though this will not necessarily happen through reliance on digital tools, it is an exciting time to be teaching geography with the breadth of contemporary accessible and user-friendly applications that can be integrated into programs. One thing is clear. Children entering formal schooling retain their imaginative curiosity and excitement regarding movement, colour and imaging. New directions for learning need to better understand the digital spaces which young people inhabit and create (Downs, 2016; Pawson, 2015), and ensure that these are used to help them develop the spatial skills needed in the post-millennial world. The logical pathway forward for geographical education is collaborating with them as co-learners.

Appendix 1: Spatial technology tools that are suitable for primary schools

Google Maps

https://maps.google.com/help/maps/education/

A guide to using Google Maps in schools.

Google Earth

https://www.google.com/earth/education/

A guide to using Google Earth in schools.

Scribble Maps

http://www.scribblemaps.com/

Students can add text, lines, images and colours to a base map at all scales from local to global. This can be saved, or converted to a file for adding to a document. May require a small monthly payment, but initial use is free.

National Geographic MapMaker Interactive
https://mapmaker.nationalgeographic.org

A very valuable resource produced by National Geographic Education that displays maps of a variety of environmental and human characteristics, some of which are suitable for Years 3–6 and possibly earlier. The maps can be examined at a wide range of scales, from the whole world to a small area, depending on the country, and one map can be overlaid on another to assist comparison. Students can make a map with MapMaker Interactive by drawing on it and adding symbols. They can then save their map as a file that can be inserted into a report or printed.

National Map

https://nationalmap.gov.au/
Generates maps for a wide range of information about Australia.

StatWorld – Interactive Maps of Open Data

https://www.statsilk.com/maps/world-stats-open-data

Students can generate maps for a very large range of indicators of development relevant to Year 6.

GIS for Schools

https://esriaustralia.com.au/gis-for-schools

Esri has mapping software suitable for primary schools, for those who are more ambitious.

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Endnotes

1 Adapted and developed from Jo & Bednarz, 2009; Liben & Christensen, 2010; Golledge, Marsh, & Battersby, 2008; Mohan & Mohan, 2013; National Research Council, 2006