Food for thought: *The mathematics of the kitchen garden*

ANTHONY LYON and **LEICHA A. BRAGG** outline how mathematics may be integrated with other areas of the curriculum when creating a kitchen garden and harvesting fresh produce.

A kitchen garden is not just a place to grow food for cooking; it is a place of sensory stimulation through extraordinary explorations and investigations into the natural world. A kitchen garden contains vegetables, fruits, herbs, edible flowers, and/or ornamental plants; and animals such as chickens for supplying eggs as well as manure for composting. The Stephanie Alexander Foundation (www.kitchengardenfoundation.org.au) believes that by teaching children in a pleasurable way about growing, harvesting, preparing, and sharing food, they can create a significant force for change (Alexander, 2010). The foundation has supported the construction of over 100 kitchen gardens nationally through grants and an online support network. Many schools build on the Stephanie Alexander Foundation's philosophy of positively influencing children's food choices through creating their own kitchen gardens to promote healthy eating. Many schools such as ours decided to run the kitchen garden independently with some financial assistance from community organisations.

Incorporating a kitchen garden infrastructure into primary schools allows students to witness first hand how the produce they eat regularly is grown.

Nice idea but where is the maths?

In relation to mathematics, the kitchen garden initiative has provided a real world context for our Year 5 and 6 students through the creation of authentic tasks that ensure the mathematics is "real and relevant" (Sparrow, 2008, p. 4). Real and relevant programs provide opportunities to generate genuine engagement and excitement in mathematics for students (Bragg, Pullen & Skinner, 2010). Engagement in learning tasks may increase when participating in meaningful and individual settings (Skamp, 2008). Switching on to learning was the aim of the kitchen garden project described below with upper primary school children at Wooranna Park Primary School in North Dandenong, Melbourne.

The kitchen garden project

The initial stage of the project consisted of a basic site plan to determine size and quantity of raised garden beds, a couple of days labour from enthusiastic teachers, parents or other members of the community, and donated materials from local businesses. Clarkson (2010) described alternative ways of watering school gardens. If the local community is not able to assist financially, one of the economic gems of a kitchen garden is that it can be constructed on any budget along with a little elbow grease. The students investigated the requirements of the kitchen garden through surveying home gardeners, and created a budget using spreadsheets (Excel) of the necessary items.

Student ownership was seen as important for creating a respectful culture within the school for taking care of their garden. This was the students' garden with which they were empowered to make recommendations, changes, and/or improvements. The students formed their own committees to assist in maintaining gardening equipment; weeding, watering and pest control; maintaining the chicken coop; and organising fund raising activities to generate monies for furthering the project.

Design

During the early stages of the project, open-ended questions were utilised to examine the design of the kitchen garden. For example, students were asked to "design to scale a layout of the garden beds to fit within the kitchen garden area while providing enough room for access". A flurry of measurement calculations ensued including length, perimeter, area, volume and capacity. The designs were elaborate and demonstrated that the students were developing understanding of scale (see Figure 1). The problem was further refined to include a condition that the sizes of the garden beds must be evenly divisible by 2.4 metres to accommodate the size of the sleepers available for purchase and not have any waste. The optimum design to ensure ease of access to all plants and cost-efficiency included the creation of garden beds that were 2.4 m x 1.2 m and two sleepers high. Students who found the mathematics of scaling drawings more challenging could work with cut out templates of the garden beds and walkway clearances to assist with their design.

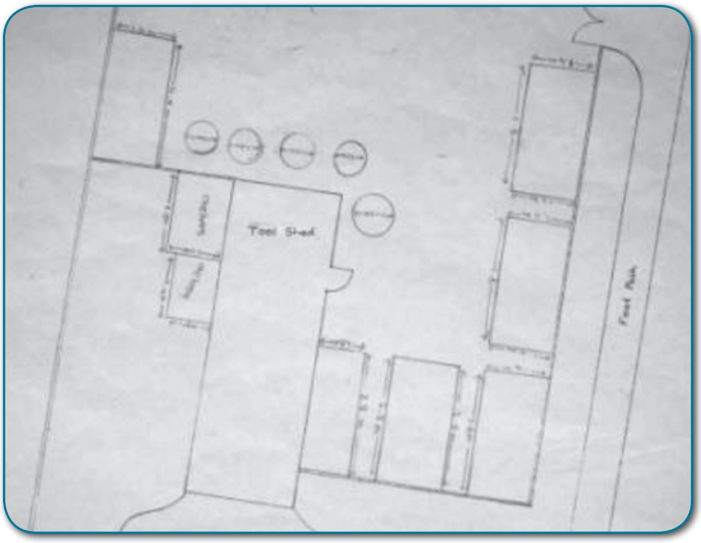

Figure 1. A student's plan for the garden bed.

Construction

The kitchen garden area was initially covered in gravel to combat mud and dust from student traffic. Raised hardwood timber garden beds were constructed, as the soil existing at the site was clay-based and lacked structure and nutrients. Raised garden beds have many benefits including: reducing the need for the physical demands of bending down; keeping the footpaths separated from the produce; and creating a barrier for keeping weeds from the crops. The construction process required adult involvement, particularly with the use of power tools. The students were involved in the multitude of mathematical computations required during the construction process and witnessed the relevance of mathematics in the real world. The students faced the typical problems associated with building a garden, such as measuring (twice) the lengths of wood for cutting (once), calculating the soil capacity of the garden bed, and ensuring the garden beds were level and plumb. The students employed appropriate mathematical terminologies (length, depth, width, height, etc.) and the garden bed construction offered the ideal opportunity to discuss the meaning of volume versus capacity. These problems added to the authenticity of the task which was noted in ther mathematics journals that were maintained by these Year 5 and 6 children throughout the process.

Installation of a water tank caused great excitement and intrigue within the school. The students explored the physical features of the tank; they felt it, banged it and walked around it. They found the water level and recorded the capacity, discussing the maximum capacity of the tank. Students began knocking on the plastic tank to hear a change in sound to identify the water level. They estimated the number of litres of water in the tank. This estimation activity proved to be a rich task in identifying students' knowledge on fraction terminologies such as half, quarter, eighth, and also conversions from millilitres to litres, just as the garden bed construction explored conversion from millimetres to centimetres to metres.

Planting and growing

The students became true gardeners and approached the planting task with gusto. They filled a garden bed with soil and an organic mix which provided an ideal growing medium for our initial vegetable crops. The students drew on their understanding of ratio to calculate the correct combination of organic mix to soil. The use of wheel barrows and shovels proved to be an educational opportunity to discuss appropriate soil weight and shovel capacity. The students' estimations included asking how many wheel barrow loads it would take to move the soil from the large pile to the garden beds. They considered the load capacity and time allowances for children compared to adults, as adults tend to move greater quantities in less time. A highlight of the planting sessions was to witness a student who is typically disengaged in classroom work become enthralled with the planting and keen to participate.

The types of fruit and vegetables grown in the kitchen garden will vary depending on local climate and access to water (many run on tank water). The selection of produce may be connected to the students' cultural background and prior gardening experiences. Many of our students shared stories of their family's vegetable patches and the produce grown at home. The students and their families were encouraged to provide seeds and seedlings from their own gardens for the school's kitchen garden. Despite the cultural diversity of the school, the initial crops consisted of traditional western garden species such as carrots, broccoli, beans, peas, lettuce and some herbs; as the seeds and seedlings were easily accessible. Over time we hope to diversify the range of produce to include more Asian-influenced choices.

We explored spacing of plants and the

requirements of individual plants to provide room to grow, as noted by the following journal entry by Tahir: "We planted several tomato plants. To plant them evenly spaces [sic] we placed them in the garden bed so we could see even distance between each plant. We did this so we could give each plant a similar sized area of space to grow".

Shay observed the varied approaches to estimating length in his reflection: "We had to plant them 50 cm apart so that they had space to grow. We had to estimate the 50 cm. Some people used their hands and some people used their fingers to estimate this measurement." Shay was also cognisant of the movement of the sun and how this would impact on plant growth, as illustrated in his comment, "We had to plant them [the tomato plants] where they would get a lot of sun, so we didn't plant them too close to the shed so they wouldn't get afternoon shade."

One of the typical mathematical tasks associated with gardening is graphing the growth of seedlings over several weeks or months. From the home gardener perspective, this activity lacks authenticity as they do not typically measure their vegetables to graph the growth. Scientists, on the other hand, may measure growth of plants to understand many different variables, for example, the effectiveness of specific fertilizers. The children were encouraged to view this task through the eyes of a "horticultural scientist". The class selected three specimens to measure from each species of vegetable; using visual estimation for the smallest, tallest and a mid-range seedling before using a ruler to measure heights accurately (see Figure 2). An average height was calculated and recorded. The students' developing understanding of the changeable nature of mean in relation to plant growth was evident in journal reflections such as the following:

> In the kitchen garden I have done some measuring of plants so we knew how big they were growing… First you find the smallest one and you measure it and record in on a sheet. Then you find the biggest and measure it. Also find a medium sized plant and measure it too, then record it. Then you have got to find the average of all of the plants and record your average. Your group know the average of how big the plants you measure have grown. If you do this on a daily bases you will get a bigger average due to plant growth. (Sara, Year 6)

Figure 2. Horticultural scientist measuring plant growth.

Over several months it can prove difficult to sustain student engagement in recording growth. To maintain the students' perseverance in the measurement task and enhance the potential for learning, ten minutes, once a week, was dedicated to recording the growth.

More lengthy periods of time were allocated to other authentic mathematical tasks that held the students engagement and connected to the wider curriculum. These included creating rain gauges, investigating ideal planting conditions, and creating organic pesticides.

In pairs, the students created rain gauges using reusable materials such as a range of different sized plastic bottles (see Figure 3). The students marked the gauge on the side of the bottle at 100 mL increments by filling the bottle with water from a measuring jug. It was pleasing to note that the students recognised that the circumference of the bottle had a bearing on the distance between the measuring marks on the side of the bottle. When positioning rain gauges in the school it

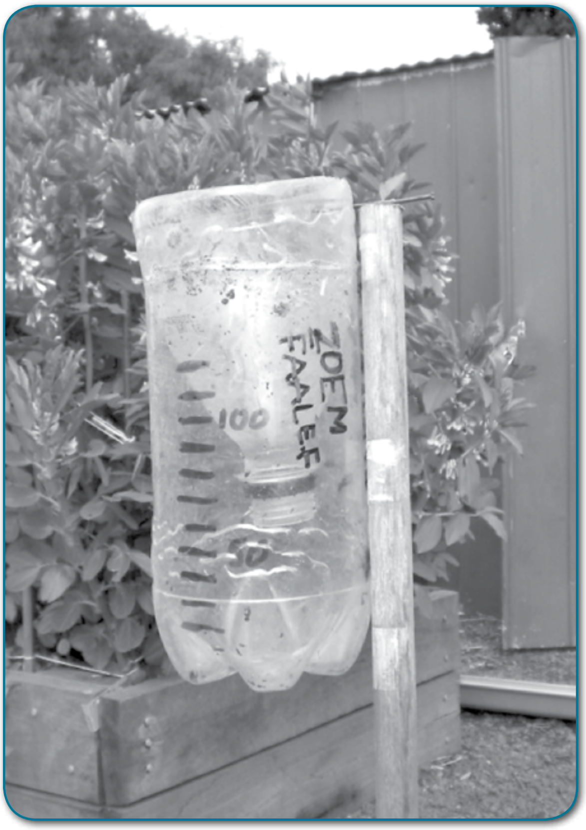

Figure 3. Rain gauge

is useful to distribute the gauges throughout the grounds to determine if different positions provide different measures and why this might occur. Helpful teachers in your school living in different areas of your town or city might erect one of the student-built rain gauges at home. They could record the data for their area by taking a digital photo of the rain gauge to provide to the students.

An indoor garden can be created to prepare and extend outdoor activities for the kitchen garden. Placing seed trays in larger shallow tubs provides environmental education as students germinate, propagate and care for seeds and seedlings. At our school, the students have set up the tubs in a bright, warm area between two learning spaces (see Figure 4). Currently, the students are growing six "bush food" species. These will be moved out into the makeshift green-house (a shed with laser light replacing corrugated iron sheets on the roof) to provide warmth, controlled watering and plenty of light for growth before planting in an area designated for indigenous plants.

Plant care

One of the real problems facing the kitchen garden is the threat of pests and diseases when growing fruits and vegetables. The students viewed an entertaining and informative animation series called Minuscule (Futurikon, 2006) via YouTube to provide an insight in the world of insects. These 4–5 minute animations involved insects and arachnids engaging in human-like parodies. The creatures displayed accurate characteristics to real insects and are shown in realistic habitats. The children became aware that insects, like those in the animations, were drawn to the kitchen garden habitat. In order to protect the garden and repel pests in a respectful way, we discussed organic methods for pest control which included mixing vinegar, garlic, chilli or numerous other ingredients. Creating the organic pesticides led to a contextualised lesson on ratio as the students were required to create the "right" pesticide mix and generate a large batch for all the garden beds. These activities proved an ideal accompaniment to the outdoor sessions especially when the weather was not suitable for outside activities in the garden. Composting too, has provided opportunities to explore ratios and saturation levels. Students combine

Figure 4. Inside seedling planters.

wet or dry material to maintain appropriate moisture levels for effective decomposition and minimising odour.

In summary

The development of a kitchen garden provided the students with an insight into the desirability of applying mathematical understandings to real-life situations. The students were engaged and demonstrated a desire to understand the mathematics required to assist in creating their kitchen garden. Journaling of the daily goings-on in the kitchen garden provided an opportunity to highlight the explicit need for particular mathematical skills to become a successful gardener. As illustrated earlier, reflections on each journal entry raised a mathematical situation that could be drawn on in the classroom. The students' excitement about learning mathematics through gardening was evident in this excerpt from a summary reflection of the kitchen garden program by Marek:

> It was a fun and organic way in learning maths and science. Everyone enjoyed the amount of maths there was though. These maths skills included scaling the growth of plants, we used capacity to measure garden beds, averages of the baby plants, and measurement which we learned while finding averages in plants and building stages of the garden bed. It was so much more fun than we expected, there was so much to learn. I was so surprised with all the maths and science I learned from the program. All the things were transformed into a fun and attractive way of learning.

The kitchen garden has also raised an awareness of sustainable living, bush plants and food, healthy eating; and inspired the students to create home gardens and try their hand at cooking using the ingredients from the kitchen garden. Our experience of the kitchen garden supports Clarkson's (2010) observation that school gardens provide a jumping off point for sustainable living issues that allow the mathematics to unfold.

Acknowledgements

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APMC

Kitchen garden unit planner

Mathematics

Measurement and geometry

Year 5 — Make connections between different types of triangles and quadrilaterals using their features, including symmetry and explain reasoning.
Year 6 — Visualise and solve problems relating to packing and stacking. Understand and use different ways of calculating perimeter and area of rectangles and volume of rectangular prisms using metric units.

Number and Algebra

Year 5 — Recognise and represent numbers involving tenths; read, write and order those numbers and connect them to fractions.
Year 6 — Apply multiplication and related division facts to solve realistic problems efficiently using mental and written strategies and calculators justifying the reasonableness of answers and explaining reasoning.
Year 6 — Recognise and solve problems involving unit ratio … and check for reasonableness of answers.

Statistics and Probability

Year 5 — Identify the mode and median in lists and on dot plots.
Year 6 — Construct, read and interpret tables and graphs including ordered stem and leaf plots, and construct pie charts and other simple data displays including using technology.

Cross curriculum dimensions

Science – Understanding – Biological Science
Year 5 — Living things have structural features and adaptations that help them to survive in their environment.
Year 6 — The growth and survival of living things are affected by the physical conditions of their environment.
Science Inquiry Skills — Questioning and predicting; Planning and conducting; Processing and analysing data and information; Evaluating; Communicating.

Sustainability — Developing an understanding of the interaction between social, economic and environmental systems and how to manage them.

Geography — Students explore effective ways to care for local places, and are provided with opportunities to initiate and participate in an action on an environmental issue of personal or group concern.

Health — Students analyse and explain physiological, social, cultural and economic reasons for food choices and analyse and describe food selection models. Students describe how to prepare and store food hygienically.

The above learning foci were selected from the Australian Curriculum (Australian Curriculum Assessment and Reporting Authority, 2010) and the Victorian Essential Learning Standards (Victorian Curriculum and Assessment Authority, 2006).

Tasks

Design garden beds

Students design symmetrical and asymmetrical garden bed layouts and explore the features of different shapes, in particular quadrilaterals, when considering the functionality and aesthetics of the design. Students are required to visualise and solve problems related to 2D and 3D design; i.e., allowing adequate space for paths and access to garden beds. Open-ended question: "Design to scale a layout of the garden beds to fit within the kitchen garden area while providing enough room for access."

Students may use garden bed templates to assist with the design phase.

Budgeting and benefits

The students survey parents and friends about their requirements for home gardens. Brainstorm items required to establish a kitchen garden.

Students search the internet to investigate the cost of items and use the MS excel program to itemise and create a budget for the kitchen garden. Students create pie charts using excel to determine the allocation of funds for particular elements of the kitchen garden; e.g., construction, plants, fertiliser and ongoing maintenance.

Cost benefit analysis comparing school grown and store bought produce: is monetary/financial cost the most important? Students analyse health and environmental benefits for kitchen garden food choices.

Construction

Students plot, measure and mark out garden bed designs in the ground using trundle wheels, tape measures, set square, string and stakes. Students measure lengths of timber, ensure garden beds are level and plumb, estimate and calculate capacity of garden beds for soil. Installation of water tank: estimate and calculate capacity for tank. Open-ended question: estimate how many watering cans the water tank would fill. Construct rain gauges for installation around the school. Focus on conversion of units for usefulness and accuracy of measurement.

Planting and growing

Students investigate appropriate plants to grow for the location. Open-ended question: Design the planting bed for our selected plants so that the plants are not overcrowded. Consider the projected height of plants so that plants to the front of the garden beds do not block access to plants at the rear.

Students collate data on plant growth and rainfall from rain gauges. Students construct appropriate graphs to represent these data; e.g., stem and leaf or bar.

Plant Care

Students/horticultural scientists investigate and create appropriate pesticides and compost for the garden. Ratio is explored to produce larger quantities of pesticides and ensure the correct moisture balance for decomposition. Students investigate and calculate the water flow required for plant hydration based on the size of the garden beds and habitation.

Cooking

Students examine recipes using ingredients of their choice from the kitchen garden. Students prepare dishes using ingredients from the kitchen garden showing understanding of hygienic food preparation procedures.