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Reimagining maths learning - insights from a Conceptual PlayWorld project

(Originally: **Adding life to maths learning: being open to surprises*)***

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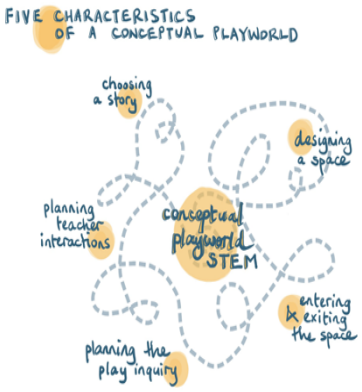
At the commencement of 2022 there was an opportunity for reimagining mathematics learning in primary schools across Victoria. Schools were seeking new interactive experiences to support engaging students, and teachers, in mathematics learning. Laburnum Primary School (LPS) participated in a curriculum development project with Monash University (MU). The school was inspired by the evidence-informed teaching model called Conceptual PlayWorld (CPW). The model's five planning characteristics offered a new way of teaching that was relevant and meaningful, framed through investigations, creative, and importantly, collaborative.

LPS undertook a detailed analysis of evidence which generated a set of strategic questions:

- Where are opportunities for realistic and authentic mathematical problem-solving?
- Can we capture what students know and understand during the learning?
- Why are our boys making more progress academically than our girls?
- Are students committed to learning mathematics?
- Can we provide a stronger emphasis on geometry, measurement, statistics and probability mathematical concepts and skills?
- How can we continue to use student interests to guide numeracy experiences?
- How can we launch an engaging mathematics learning experience?

LPS staff used the following data to inform our practices: Department of Education (DE) collated and triangulated data from students, teachers and the community, student responses to a DE productive mindsets and dispositions reflective survey by EdPartnerships (2021), and conversations with students related to their beliefs on what hinders and helps learning mathematics.

The result was a whole-of-school 2022 professional learning (PL) inquiry with an overall driving question: 'How might we design and facilitate maths for the right level of challenge and spark engagement for all learners?' CPW, with its 5 characteristics, was adapted to function as our planning tool to define and direct an engaging and robust learning experience to explore mathematical development. PL facilitated by the MU team, supported teaching teams to unpack the five characteristics. The CPW resources were made available to LPS and can be accessed here:



The five intentional and targeted CPW characteristics are:

1. Choosing an engaging and dramatic story.
2. Designing an imaginative space.
3. Entering and exiting the space.
4. Planning the play inquiry.
5. Planning teacher interactions. (Figure 1).

Figure 1 Interconnections between the MU CPW five planning characteristics

A planning document for preparing CPW focused lessons was utilised in the PL sessions. [see examples here: https://www.monash.edu/conceptual-playworld/educators/create/starters]

A self-paced CPW PL, can also be found here:

Each teaching team at LPS worked with the five characteristics at their own pace and comfort level. There was lots of laughter as teachers designed spaces and props for the CPW explorations, which included imaginative spaces such as a forest, company boardroom and toy workshop to set the scene for a challenging mathematical problem to emerge. Colleagues were invited into each other's learning communities to contribute to the mathematical discourse, support learner discoveries and experience the buzz.

The stance of leaders in the CPW was as collaborators: learning with and alongside teacher colleagues, engaging in the joint creation of learning play spaces, with an unerring focus on collegiality, collective agency, and curiosity. A number of observing to learn strategies such as team teaching, student shadowing, and lesson study became options to support deeper learning within and beyond the teaching teams. These peer observation strategies offered a school-based context to try out, adapt, apply, and authenticate ideas in their classrooms.

After the first experience, the staff stated they felt re-energised by the different form of mathematical learning that the CPW offered. The project team identified evidence of an increased sense of wellbeing amongst teachers, and a revitalised enthusiasm for

mathematics learning and teaching as reflected in this teacher comment: 'The CPW experience returned some of the things that had been missing over the last couple of years in learning and teaching.' It was agreed that each teaching team would design at least two experiences with students in 2022.

During regular reflections the following key themes emerged:

- Engaging and scaffolding all students, particularly students with English language learners
- Anticipating and supporting differentiation.
- Assessing levels of achievement / engagement.
- Prioritising experiences of longer duration, offering time for exploration; and
- Creating new learning experiences using the five characteristics.

Documenting and discussing "What makes a *Great Maths* learning experience at LPS" drove the PL conversations. The teachers used reflective scaffolds to draw out 'wins, obstacles, and wonderings' within and across teams to design CPW learning experiences, as shown in Table 1. They sought a positive impact on mathematical problem-solving via realistic and authentic problem scenarios and stronger, more willing engagement in maths by girls.

Table 1. CPWs for mathematical engagement and deep learning:

Year Level & text	Mathematics Concept	Problem posed	Key mathematical questions	Insights
Foundation-Designers Room on the Broom by Julia Donaldson	Comparison Length - informal units to formal units	Students used measurement to construct a new broom that was long enough for the witch and her friends.	What length might we need for a broomstick that carries a dog, cat, bird, frog, and a witch? How long is it? Is it long enough?	The teacher's role was to prompt students' methods to compare length. The students used multiple ways to check their broom length leading to connections between informal and formal methods to measure. They explored measurement beyond the suggested level of curriculum. (Figures 2 & 3)
Junior - Toy Makers Ingenious Jean by Susan Chandler	Visualisation Proportion	Students designed and created toys (using 2D shapes and 3D objects) to help Santa while elves were in Covid lockdown.	How might an object support a solid construction for a toy? What shapes and objects can we use for features on our toy?	The students' role as inventor nurtured the disposition of resilience. Helping solve a problem for Santa took the responsibility of inventor to a whole new level. The teachers' role as Elf supervisors prompted students to stay in their role to design and create toys.

Junior - Detectives Secret Birthday Message by Eric Carl	Visualisation Regular and irregular shapes	Students read and interrupt clues with shapes to find a lost puppy. The clues were in a letter.	What does this shape have that helps us name it? What clues link to shapes in my playground?	Representing the journey as a map provided insight into students' understanding of direction. Students connected the language of direction with shapes.
Middle - Shop owners Pete the Cat's Trip to the Supermarket by James Dean	Money value Addition and subtraction Geometry	Students created food from 2D and 3D objects to sell to other classes. They provided price lists where multiple purchases offered discounts. They used current shopping catalogues for reasonable prices. Each student had to budget for the groceries for the week.	What is the average price of that item? How can you calculate the change? (Figure 4)	The cross-class experience enabled a diversity of foods. Before closing shop owners placed discounts on their fresh foods. Students loved to shop for paper and plastic foods! The money exchange supported the current class money value unit.
Middle - Activists Whatcha Building? by Andrew Daddo	Representing and interpreting data into action Measurement - length, perimeter, area, legend, and scale	A problem was announced through a letter from 'little Davey' (character from the book) warning students that a loved play area was being turned into a carpark. Students then entered the proposed site to gather data to convince the school council to keep the play area. The students collected people's views and ideas to persuade an imaginary School Council to save a treasured space.	How can we map our space? What could we add to our treasured space? What are the opinions and views of others who might use this space? What is the most popular view? How could we represent these views?	Teachers took on characters such as the developer (the villain), fellow activist, parent, council worker, and school principal. Students pretended to be and enjoyed being designers, community members, 'little Davey', data collectors, and statisticians. There were more interactions and discussions than in a maths classroom setting because of the purpose and emotion. Students' ideas for how the space could be saved included representation of data as graphs, statistics and lists and birds eye view map and model. All students engaged and saw maths including measurement, statistics and probability.

				Creating a new use of the space linked to the focus on wellbeing, community problem-solving and communication.
Senior - Town Planners Imagine a City by Elise Hurst	Estimation Area to Population Percentage of an area	Students worked in teams (companies) to design a new city. Each company had departments to inform the quantities and cost. They proposed their ideas, costs, and reasoning to the self-appointed mayor of the city, Mr Chazman.	Is estimating enough in most of our mathematical judgments? Do we need accuracy? What effect does accuracy have on our proposal?'	Teachers acted as company directors and assistants to the mayor. They kept the flow of the design after board meetings. Students took roles that interested them. They were committed to the pitch and responded to the details of the mayor's request e.g., 50% green space, population of 5 million with 60% families. Students wanted to be part of the experience and ensured other out of class learning during 'build a city' experience was rescheduled. The cross-class experience added to the rigour in the learning.

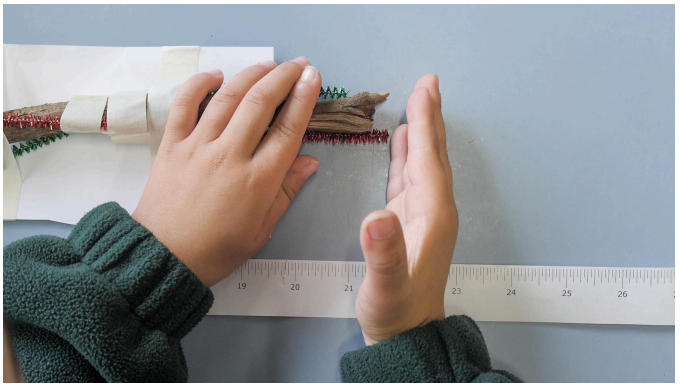


Figure 2 Designer: Student using hands as a measure to compare, noticing the red part is longer.

Figure 3 Designer: Reading a scale on a formal ruler when designing a broom for animals.

Figure 4 Shop owners: Students calculating change.

Most year level teams allocated a full week to introduce or refresh mathematical concepts before launching their planned CPWs – and what a buzz emerged from staff and students alike with some of the 'wins' identified amongst students which include:

- Being strongly motivated to find different solutions, evident in the levels of energy, engagement, and problem-solving-persistence across the whole cohort of learners,
- Establishing maths as a source of enjoyment and well-being when exploring different parts of the school, as prompted by the CPWs,
- Having fun, as learners immersed themselves in the imaginative reality of the CPWS,
- Exceeding teacher expected mathematical development levels,
- Landing in creative learning places which teachers were not expecting,
- Tapping into the enthusiasm that emerged amongst peers, which encouraged reluctant students to enter into and participate in the imaginary learning spaces,
- Recognising maths is around us in all contexts,
- Collaborating, discussing, and debating as catalysts for maths learning,
- Inventing different forms of communication to share insights and understandings,
- Loving the opportunities to communicate with the role-playing characters which populated and supported the CPWs,
- Demonstrating learning via the artefacts they created and actions they took,
- Enjoying being in character, which seemed to free up their capacities and willingness to freely share their thinking and solution pathways,
- Leading the direction of the exploration scaffolded by teachers in character, and

- Having unexpected and incidental learning opportunities that were generated by the CPWs.

Below are examples of how CPW were orchestrated across year levels.

Characteristic 1: Selecting a book/story - be relevant.

The first characteristic to consider in developing a CPW, selection of the story, played a significant, formative role in the process. The connection to the characters or concepts in the book enabled richer experiences to support a more purposeful problem-solving situation. Some of the teachers trialled books first to gauge interest and curiosities. One teaching team noticed the students' strong connection to the puppy in the text. This assisted in developing a CPW experience relating to finding a lost puppy using coded messages (Figure 5). The team also selected a shape focus as students had prior knowledge to enable success for all students including English language learners.

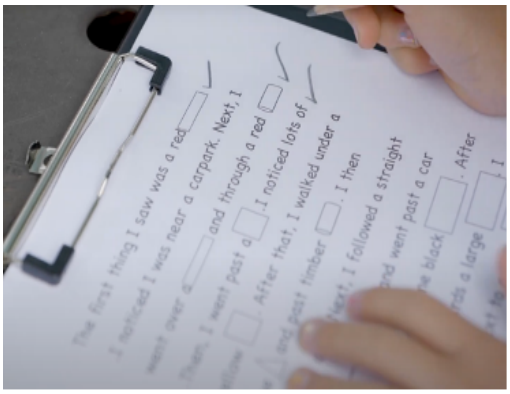


Figure 5 Detective: Finding a lost puppy using coded messages.

The middle years teaching team selected a book with a young character 'Little Davey' where the storyline acted as CPW problem of pulling down something that is loved.

The school librarian became a central part of the dialogue and offered perspective around texts that could support a particular mathematical concept. The books opened the mathematical content areas to geometry and measurement. Teachers claimed, 'I've read this book many times, never used it for maths and there is so much maths in it', and 'using the same books for reading, writing and maths creates even more meaning.'

Characteristic 2: Planning the imaginary space – be meaningful.

Much of the imagining happens in the space designed by the teachers – such as an area of the playground that is taped off where the CPW is a play area that is being turned into a carpark (Figure 6) or an empty classroom to act as a boardroom where students in teams (companies) design a new city (Figure 7).

Figure 6 Activist: Proposed site cordoned off with construction tape and a sign.

Figure 7 City Planners: Long table for Boardroom

Numeracy Improvement Guide for School Leaders (DE, 2022) offers a model of numeracy to support strong learning experiences in a CPW. The Goos, Geiger and Dole's model of numeracy describes four elements:

- Element 1: Attention to real-life contexts within and beyond school settings.
- Element 2: Application of mathematical concepts, skills, strategies, and capacities.
- Element 3: Use of materials and tools to mediate and shape thinking.
- Element 4: Confidence, flexibility, and willingness to use mathematics to solve problems encountered in life related tasks.

CPW offers multiple contexts beyond the mathematics classroom. The CPW experiences (Table 1) also required the interpreting of mathematical solutions to persuade or shape opinions about a social issue. Middle and senior teachers were very aware that the context for their learners had to have real world connections. One team of teachers noted the English language learners were also more likely to engage when the context and language was connected to a familiar experience like shopping, animals, and toys.

Characteristic 3: Entry and exit – be investigative.

The entry and exit into a CPW helped keep the experience fresh and in context. Subtle props helped clarify roles and define when the students and teacher were in character. The entry/ exit indicator ranged from lanyards (Figure 8) to the carrying of tools to indicate investigation

(Figure 9). The props confirmed the duration of the exploring and reviewing phase. This helped when teachers noticed a mathematical skill or concept required a re-introduction away from the CPW problem solving.

Figure 8 Toy Makers: Lanyards worn when in character creating toys form 2D and 3D materials.

Figure 9 Detective: A spy glass as the detectives entered the playground to find the lost puppy.

Characteristic 4: Problem to be solved- be creative.

An authentic problem motivates learners into mathematics. Most experiences used a message to launch the mathematical problem, such as “How can we collect and present evidence to the school leaders to stop the playground becoming a carpark?” The problems arose through interactions with the characters from the book. These ranged from letters from a character (Figure 10), audio messages from a barn and video footage from a private jet. These communications offered a launch and relaunch into problem solving.

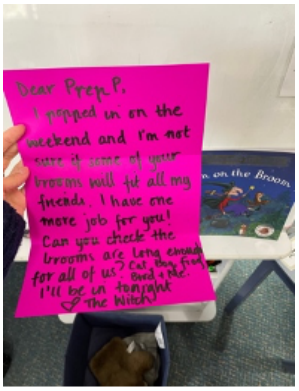


Figure 10 Designers: Second letter from the witch to compare lengths of their broomsticks.

Questions that supported the conversations were the ReSolve reasoning prompts (Mathematics by Inquiry, 2018). It was common to hear teachers and students stating: 'if we change this what might happen?' and 'how could we prove that it is true?' Next steps for the teaching teams are to further develop understandings around key concepts in mathematics to support the questioning during the explore and review phase.

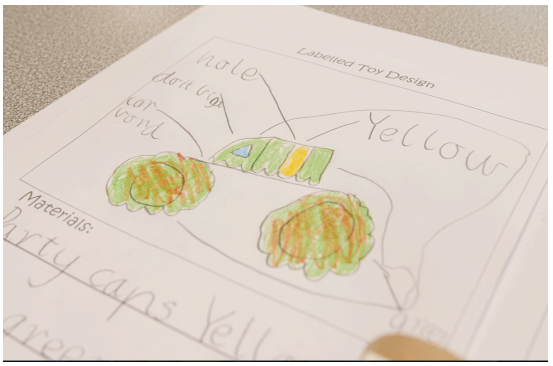
Characteristic 5: Planning interactions- collaborative

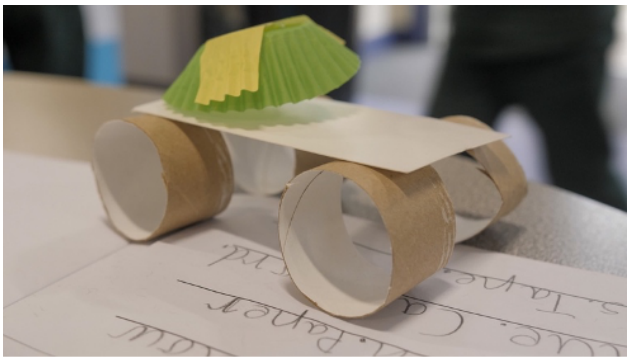
In a CPW the teachers also act in role. For example, in designing a city with an imaginary area of the board room, one of the teachers dressed in a suit as the assistant to the CEO. Another teacher wore a high visibility jacket. The students took a key role in the companies that formed in the different classrooms (Figure 11) and they in turn took their planning and associated budget documents to the board room. A significant feature of the imaginary play was being in character solving the problem.

Figure 11 City Designers: Company directors coming together to collaborate on costings and quantities.

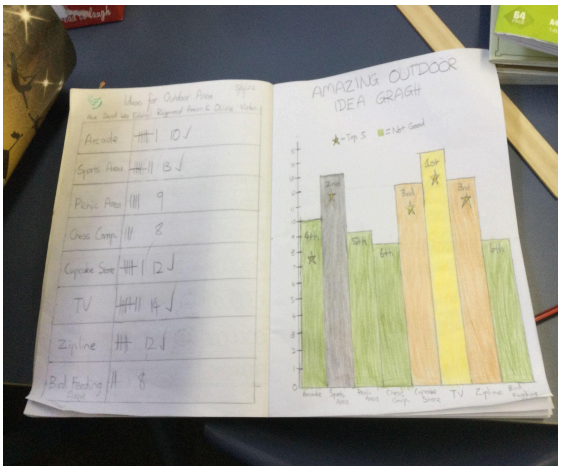
A lot of thought went into what the CPW would look like, the problem to be solved, and the anticipation of students' responses. By term 4, teacher confidence, creativity, courage and researchfullness to design a CPW experience was noticeable.

Teachers were conscious of using the developing artefacts as conversation points with students around their progress. Below are some examples (Figures 12-15) that supported conversations, moderation, and assessment of the learning.





Figures 12 & 13 Toymaker: Students recorded their work using labels, pictures/ and text.



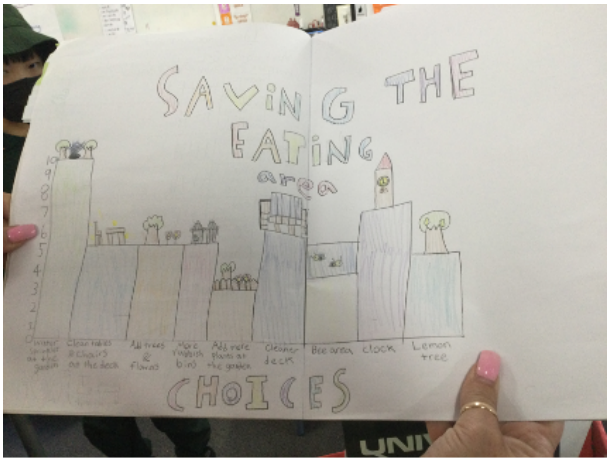


Figure 14 & 15 Activists: Students representing their data in two forms to state the views of the people about potential use of the space.

Final Comments:

Key indicators of success included evidence of deeper thinking, the emergence of investigative and experimental approaches to learning, which benefited from slowing down the pace, the open-endedness of the problems, an emphasis on questions to promote curiosity and investigation, and the multiple ways students could represent ideas.

The students taking a lead was also a success factor in the senior classes. Feedback from students indicated that they knew they were learning. One student stated: “I am the Head of Emergency Services: my teacher is my CEO. Being in charge is hard … I have never built a city before. However, I have experience building cities through Minecraft and Lego, but no experience in budgeting and working out the ratio of population to quantities of hospitals and equipment.”

CPW has supported the re-imagining of learning and teaching at LPS. CPW offered relevance and meaning, investigative, creative, and importantly, collaborative ways in mathematical learning. The experiences of students and teachers is likely to have a lasting impact and will continue to inspire new and innovative ways to promote the joy, and love in mathematical learning.

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