Maaku anoo e hanga tooku nei whare
I will build my own house

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INTRODUCTION: The context of the project

The proponents of Modern Learning Environments (MLE) or Innovative Learning Environments (ILE) are from largely non-indigenous backgrounds. In Aotearoa New Zealand, research about learning mathematics in an MLE is limited and focuses almost exclusively on English-Medium (EM) settings (Bisset, 2014; Murphy, 2016; Osborne, 2013). In contrast, this research sought to contribute to the literature and knowledge space about tamariki learning paangarau (mathematics) in a Maaori-medium MLE. It provided an opportunity to locate and explore Maaori-medium (MM) ways of knowing and doing and for MM kaiako to consider the MLE space and identify characteristics of an MLE appropriate for them and their aakonga. The research grew out of an interest and desire to explore the transition process for kaiako and aakonga from single-cell classrooms to the larger physical space. The introduction of MLE into the kura in this research occurred in 2017, during which time researchers and kaiako became interested in investigating paangarau teaching and learning in their Years 4–6 MLE.

The title of this project, Maaku anoo e hanga tooku nei whare (I will build my own house), is the first line of a tongikura (prophetic saying) by Taawhiao which makes reference to building a house fashioned from trees not known for their building potential (hiinau, maahoe, and paatate), implying that you build what you want with what you have. Taawhiao called for his people to be nurtured by the rengarenga (rock lily) and strengthened by the kawariki (coprosma) berries. He set in motion the vision for iwi to take responsibility for building their own whare where people are the foundation (Papa & Meredith, 2012). A modern interpretation of the tongikura for this research positions kaiako and community as key to determining ways forward to advance the aspirations of tamariki mokopuna and the community.

As part of taking responsibility for building our own whare, the research team has taken time to explore and suggest a Maaori name to adequately capture the intent of an MM MLE. A Puna Maatauranga Kiritoa (PMK) is presented here as an outcome of discussions held; Puna being a spring (of water), Maatauranga meaning knowledge or education, and Kiritoa the notion of being resilient or strong in oneself. Conceptualised as a PMK, this version of an ILE or MLE is an environment that involves quality teaching and learning in a range of spaces while demanding a high level of self-management and resilience from kaiako and aakonga in order for all to flourish.

Referring to MLEs, Bisset (2014) and Blackmore et al. (2011) suggest the changes involved for kaiako and aakonga in moving to an MLE environment might be described as tangible (physical elements, such as buildings, furniture, and technology) and intangible or abstract such as pedagogy. However, as Bisset (2014) states, "The effectiveness of the MLE is largely determined by the ability of the staff and community to support and enact the intangible, pedagogical changes that are needed to establish their vision" (p. 1). There is considerable potential to explore innovative teaching and learning of curriculum (including paangarau) within ILE spaces.

The research questions negotiated for this project are as follows:

1. What are kaiako views of teaching and learning paangarau for Years 4–6 in this MLE?
2. What are aakonga views about the challenges and advantages of learning of paangarau in this MLE?
3. How can kaiako leverage the affordances of this MLE to strengthen the engagement and achievement by aakonga in paangarau?

Hence, this largely qualitative research investigated kaiako and aakonga views about their experiences in an MM MLE as a site of innovative teaching and learning in paangarau. Key ideas involving fostering productive learning pathways, the nature of collaboration, affordances offered by the research MLE, and the role of hangarau matihiko or digital technology for teaching and learning paangarau, were explored and are shared. The research also sought out a deeper understanding of the nature of teaching and learning through the medium of te reo Maaori in an MLE.

FIGURE 1. **An external view of the Modern Learning Environment (MLE) featured in this research report**

The significance of the study to Maaori medium settings

The timing and focus of this research is important given government policies emphasising the importance of enhancing aakonga Maaori engagement and achievement in paangarau (Ministry of Education, 2013). The promotion of MLEs as sites for developing aakonga as 21st century learners is considered essential (Bolstad et al., 2012). These imperatives make it important to elicit kaiako and aakonga perspectives in English and MM about how the MLE learning and teaching space is impacting on pedagogy compared to that enacted in their previous environment (a single-cell setting). The effect of the evolving practices in an MLE and their impact on engagement and achievement of aakonga also warrants exploration. Te Wharekura o Raakaumanga and other MM settings require focused opportunities to waananga (explore and debate) any new innovation that might affect educational outcomes for aakonga, if only to adapt and ensure the worthiness of such initiatives for their goals. Supporting kaiako, aakonga, and researchers to engage in robust research therefore is a responsibility and a necessity.

FIGURE 2. **Front view of the MLE featured in this report**

Research design

The participants in this research were 106 tamariki and six kaiako from a Years 4–6 PMK at Te Wharekura o Raakaumangamanga. All kaiako and tamariki were invited aa-kanohi (face to face) and with a hard copy invitation sheet approved by the Te Kura Toi Tangata Ethics Committee, University of Waikato, to participate in the research. Formal consent was also obtained from the tumuaki (principal).

Kaupapa Maaori methodology with action research was drawn upon to ensure the research was undertaken in a way appropriate to the participants as Maaori. Smith (1999) notes the importance of recognising the validity and legitimacy of Maaori language and culture, including the Kingitanga, of connections to Maaori philosophy and principles, and the need to recognise the unique journey of each individual, whaanau, iwi, hapuu, and kura. In this study, all of these ideas were affirmed, as the kura strived to enact the ideals presented in the tongikura; that is, taking responsibility for advancing the aspirations of their community.

Kaupapa Maaori research methodology is strengths-based, and centred around respectful relationships and culturally embodied narratives which align to Maaori worldviews (Smith, 1999). Principles such as whanaungatanga (relationships), ako (teaching and learning), and waananga (exploring and debating) were utilised in the following ways:

- *Whanaungatanga:* The research was undertaken in ways that enhanced positive relationships amongst researchers, and kaiako and aakonga, based on trust. Both researchers had long-standing relationships in the kura. They understood the goals and aspirations of the kura and the importance of research for tribal development and educational improvement.
- *Ako:* A key tenet of this research was ako, which was conceptualised as a reciprocal learning and teaching process involving kaiako, tamariki, and researchers at Te Wharekura o Raakaumanga.
- *Waananga:* Waananga as a concept ensured there was sufficient time to negotiate, review, explore, and debate ideas as they arose. At key stages of the project, time was taken to review, deconstruct, reconstruct, and co-construct teaching and learning for aakonga and kaiako. Waananga provided further opportunities for researchers and their partners to explore both kaiako and aakonga views of teaching and learning paangarau and to narrate and extend those views and experiences.

Action research involves critical reflection on practice and theory-practice conversations along with ongoing and evolving action as part of that (McAteer, 2013). Action research was embedded in the project under the umbrella of Kaupapa Maaori as part of the circular process followed by kaiako as they sought to inquire into their practice in order to support and improve learning in paangarau for tamariki in their PMK.

Data collection methods

Online surveys were used to give all aakonga in the PMK a voice and to generate quantitative data. Survey questions focused on exploring aakonga attitudes to learning and teaching paangarau in a large room with 99 other learners and six kaiako. Questions linked to factors in the physical and social environment that aakonga might consider affect their engagement. Due to the age group range of tamariki, surveys were administered with the support of kaiako.

Aakonga in this research were also asked to write and complete the sentence "He rite te ako paangarau ki te …" (Learning paangarau is like …) and then construct an illustration depicting their idea. Following this they were also asked to write a sentence explaining their reasoning. Aakonga drawing as a means of sharing their thinking about learning in the classroom can be a valuable tool for providing feedback (Harris et al., 2014).

Classroom observations by researchers were conducted in both years of the study in order for them to better understand the nature of teaching and learning paangarau in this PMK.

Hui were initiated with kaiako and aakonga to explore relevant ideas. Within these, a focus group methodology was selected as the most appropriate mechanism for generating some qualitative data. Focus groups generally include the selection of a small group of participants who share similar characteristics such as ethnic, social background, and age range (Silverman, 2014). In this study, focus group koorero with aakonga were undertaken separately to those with kaiako. Data from the online survey in Phase One were used to inform questions for guiding the semi-structured koorero with aakonga in 2018 and 2019. This process provided some basis for comparing aakonga thinking across the 2 years. Questions for semi-structured koorero and other hui with kaiako were designed to explore their thinking about past, current, and future teaching practices, as well as goals for aakonga learning and engagement. All koorero with kaiako and aakonga were recorded and key ideas transcribed at a later date.

Phase One: 2018

The aim of Phase One was largely to gather data from kaiako and aakonga about their current teaching and learning views and practices for paangarau in the PMK. Where possible, kaiako reflections included comparisons with their teaching and learning experiences in previous single-cell settings.

Data gathering activities in this phase included:

- one hui with Senior Leader
- three hui with five kaiako teaching in the PMK
- one hui with two senior leaders to discuss achievement data
- one focus group interview with eight Years 4–6 aakonga
- five observations in the PMK during paangarau learning times
- researchers journalling observations
- one online survey with 99 aakonga
- one set of illustrations by aakonga.

Phase Two: 2019–March 2020

The aim of Phase Two was for kaiako to identify a focus feature that they felt would enhance the teaching and learning of paangarau in the PMK. Feedback from the 2018 online survey, illustrations by aakonga, and earlier conversations with kaiako and aakonga were shared to guide the process. After much discussion it was decided to focus on planning tasks that offered learners opportunities to engage deeply with the paangarau while increasing their self-management skills. Tasks for the first 3–4-day teaching and learning experience (Cycle 1) were planned and a week was selected early in Term 2 for implementation. Following the evaluation of that teaching and learning experience, further tasks were planned for another 3–4-day cycle (Cycle 2).

Data gathering activities in this phase included:

- one hui with five kaiako to identify possible feature for focus, with justification
- three planning hui with five kaiako to develop teaching and learning tasks
- researcher field notes recorded
- six observations by researchers in the MLE during paangarau learning times
- six debrief hui with five kaiako following teaching sessions (feedback and feedforward given to kaiako)
- one online survey of all aakonga
- one focus group interview with seven Years 4–6 aakonga
- one interview with tumuaki
- one set of audio recordings of three to six aakonga sharing their views after teaching and learning focus implemented
- one full debrief between four kaiako and researchers about the effectiveness of their selected focus and strategy for enhancing the participation, motivation, and learning of aakonga in paangarau.

Data analysis

Data analysis was driven mainly by qualitative approaches focusing on key themes regarding kaiako and aakonga views about teaching and learning paangarau in a PMK. A mixture of quantitative and qualitative data was woven throughout the presentation of findings to support the exploration of the advantages, challenges, and affordances of this environment, as emphasised in the three research questions. The online survey and children's illustrations were drawn upon for quantitative data, while the focus group interviews, observations, and debrief with kaiako provided examples of qualitative data.

A thematic approach to data analysis is often used in qualitative research (Thomas & Harden, 2008). This method is utilised here to honour key views and perspectives from aakonga alongside consideration of Kaupapa Maaori ideals and important ideas and questions posed in literature. The thematic method of data analysis supports the presentation of findings as a story, easily accessible for classroom kaiako.

Findings are reported under significant themes that help to illuminate experiences of aakonga and kaiako in the teaching and learning of paangarau in this PMK. The themes are critical elements that emerged from the data and relate to all three research questions. Each theme is presented and discussed, along with examples, to provide insights into how teaching and learning paangarau in a PMK might be viewed, considered, and strengthened for future experiences.

Key findings

As noted earlier, *Maaku anoo* e *hanga tooku nei whare* implies that you build your house with the materials you have available. This tongikura positions kaiako and aakonga to explore, grapple with, and develop teaching and learning experiences in their PMK in a way that makes sense to them. They take responsibility for the experiences in their whare and how they occur, understanding that if they shirk that responsibility, someone else will (or will not) shoulder it, the results of which may be unpalatable to the PMK community.

The themes that emerged from our data analysis include ideas about the nature of collaboration, strategies for learning, and the use of digital technology by kaiako and aakonga. A thematic approach best presents the perspectives of these participants and reflects on the current literature, to make sense of learning and teaching pāngarau in this PMK. The responses to the research questions guiding this project are woven throughout the findings as part of identifying the challenges, advantages and affordances of learning pāngarau in a PMK. The three themes that resonated with our kaiako as matters worthy of attention by others are:

1. Mahi ngaatahi—Encouraging collaboration
2. Huarahi ako—Fostering productive learning pathways
3. Hangarau matihiko—Prioritising digital technology.

KEY FINDING 1. MAHI NGAATAHI:
Encouraging collaboration

2018 Phase One: Collaboration amongst kaiako

Kaiako thoughts on establishing collaboration

Findings at the initial stage of the project in May 2018 indicated that the six kaiako in this PMK agreed there were some advantages to their teaching practice afforded by this environment. These advantages included them working more collaboratively to share ideas about their practice, grouping aakonga across the whole PMK so as to gain more focus in their teaching, and to work to their strengths.

Specific details discussed were:

Ability grouping across the PMK lessened time spent on planning and encouraged more focused teaching

Prior to working in a PMK, each kaiako was responsible for teaching a range of aakonga for paangarau in their single-cell classroom and did so by organising them into three to four ability groups. Kaiako then planned activities on a daily basis for each of the different groups. Upon entering a PMK environment, kaiako realised that one of the affordances of teaching 106 Years 4–6 aakonga as a team was that tamariki could still be ability grouped with each kaiako required to plan for and teach only one level of aakonga for paangarau. This organisation of tamariki lessened considerably the amount of time spent on planning, with kaiako feeling they were better able to meet the needs of aakonga.

Collaboration/Mahi ngaatahi enabled kaiako to work to their strengths

Collaboration meant that one kaiako was able to draw on her experience and relationships to offer guidance to the team by providing an overview of the paangarau objectives to be taught over a 2-year period. Her mana in this curriculum area and long-standing relationships with the others was acknowledged and appreciated. Another kaiako provided leadership in te reo Maaori for teachers who were less confident with the specific vocabulary required for teaching and learning paangarau. These arrangements ensured there was shared understanding across the team and consistency of expectations and practice.

More opportunities to observe, ask questions, and discuss ideas with colleagues strengthened their practice

While kaiako initially felt somewhat exposed in their teaching and learning practice in a large room shared with others, they were appreciative of the opportunities afforded by the PMK environment to observe the pedagogical approaches and interactions of their colleagues with aakonga. Subsequent questions, comments, and ensuing discussion came to be viewed as moments of ako (teaching/learning) for kaiako, designed to strengthen team practice and approaches for aakonga learning in the PMK.

Challenges to collaboration for kaiako

Kaiako also shared challenges they experienced in the early stages of working in their PMK. These included:

Design of PMK impacting on collaboration, organisation, and management of learning experiences

The design of the building that housed this PMK posed some challenges for kaiako in terms of managing themselves and their aakonga in a large, open space. The building is L-shaped with one break-out room near the centre. Kaiako felt that the organisation and management of effective working areas with and for tamariki was an issue because there were few defined spaces, which allowed aakonga not engaged in productive paangarau thinking to wander and disturb others. Limited storage, access, and retrieval of paangarau equipment could also be time consuming for tamariki and kaiako due to the location and limitations of storage space. It is essential that those who are involved with the design and concept phase of the building of an MLE environment clearly involve teachers in this process (Jensen, 2019; Ministry of Education, 2015; OECD, 2017).

FIGURE 3. **An example of storage in this MLE/PMK**

High number of aakonga across a broad age range in a PMK requiring careful planning for optimal learning

When establishing a new PMK it would be useful to keep communication lines open between aakonga, kaiako, and leadership to ensure learning conditions are optimised for all. These kaiako felt that the number of aakonga was a challenge in the allocated building space. The teaching and learning of groups of tamariki as well as the movement of aakonga on various occasions proved awkward at times, resulting in excess noise and time wasting.

Furthermore, these kaiako felt that the age range of aakonga within the PMK when the overall group exceeded 100 was problematic. This PMK was for Years 4–6 which they considered to be a wide age span with regard to the physical and cognitive development of aakonga. Tracking and ensuring productive learning for all proved to be a challenge at times for both kaiako and aakonga. Some kaiako felt a Years 5 and 6 PMK would enable them to better cater to the needs of aakonga.

FIGURE 4. **A range of furniture in this MLE/PMK**

Other kaiako across the kura affecting learning in the PMK

Kaiako indicated that collaboration was essential, not just for those directly within the PMK but also with other staff in the kura. In this PMK, some aakonga were timetabled to attend their reo Paakehaa class during the paangarau learning time which affected the teaching and tracking of children's progress. The results of such scheduling became more challenging with the mixed-ability group teaching that emerged (through aakonga making choices about the tasks they wished to engage in) over the course of the research. At the end of the study, the tracking of children's learning looked even more complex, with groups rotating to different tasks on a weekly basis.

2019 Phase Two: Collaboration amongst kaiako

During 2018, it proved challenging for six kaiako to meet aa-kanohi to discuss ideas for teaching and learning for the research. In order to better manage their time and facilitate ease of collaboration, kaiako elected to work in two teams. Both teams decided that they wanted to focus on increasing children's engagement and self-management in their paangarau lessons**.** While online survey data (67%) and aakonga illustrations (60%) from 2018 indicated that most tamariki in the PMK had a positive attitude towards learning paangarau, the voices of the remaining participants were less enthusiastic. Implementing strategies to increase engagement and self-management by aakonga gained prime importance for kaiako. To support the achievement of these goals, one team chose to focus on developing tasks while the other paid particular attention to the use of relevant contexts.

The findings in this report focus largely on one group of three kaiako who decided that they would attempt to provide three tasks for aakonga to choose from, in order to increase opportunities for engagement and self-management. Tasks were designed to:

- encourage collaboration
- promote the use of equipment
- offer opportunities for self-management
- allow for differentiated learning.

In this PMK, these three kaiako became even more collaborative with regard to their planning, pedagogy, and assessment practices. Increased collaboration meant the three kaiako discussed, shared, and agreed on the paangarau topics and broad ideas for tasks to focus on and use in their teaching for the study. Key paangarau ideas in a given strand were identified, with kaiako each refining a task, then sharing it with the others to clarify and gain feedback. It was decided that each task should require aakonga to explore important concepts and ideas in depth over 3–4 days instead of in a single lesson. The following tasks were undertaken in Cycle 1.

Task 1: Rotation, reflection, translation (Tapawhaa rite e rima/Pentominoes):

- How many different shapes can be made with five squares?
- How many ways can you arrange five squares to make a two-dimensional shape?
- At least one whole side must touch a whole side of another square.
- Your shape counts if it cannot be slid, rotated, or reflected onto by another shape made with five identical squares.
- How could you arrange all of your tiles in a 5 x 12 or 6 x 10 rectangle?

Task 2: Measurement using metres, centimetres, and millimetres (Whakatautata me te ine/Estimation and measurement):

- In groups of four, choose five objects/aspects of the room.
- Split into pairs and estimate the length of those five objects/aspects, record, then measure them. Compare results with the other pair.
- Who has the smallest difference between their estimation and actual measurement? One point for the winning pair.
- What other objects can we estimate the length of?
- Whose estimation is getting closer to the actual measurement?
- What units are we learning to use when we estimate or measure?

Task 3: Measurement of area (Te horahanga/Area):

- What two-dimensional shapes can be made with 24 metres/sticks for fencing?
- What four-sided figures can we make with 24 metres/sticks?
- What is the area of each shape?

- Which shape will give the largest area?
- What other shapes can be made with 24 metres/sticks and which of those has the largest area?

Kaiako felt that the planning and sharing of largely investigative tasks meant that the demand on each of them to develop and present a range of different activities every day for aakonga was lessened. They considered also that by offering tamariki choice of tasks to engage with, aakonga were provided with opportunities to better manage themselves while exploring key paangarau ideas in depth. The nature of the tasks, including the use of equipment and collaboration between aakonga, provided occasions for differentiated learning to occur. Kaiako viewed differentiation as an essential element when learning paangarau in a Years 4–6 PMK. All tasks were worked on by aakonga at the same time, with kaiako expecting them to show evidence of their learning and understanding of key paangarau ideas appropriate for their level in the curriculum. Each group was mixed ability as aakonga selected the tasks they wished to engage with.

To reassure the team of curriculum coverage, and allow them to better support each other in the large PMK space should the need arise, kaiako shared aa-kanohi and online their task with their PMK colleagues before beginning the learning experiences. They each confirmed the mathematics inherent in their task and identified resources and requirements as well as any particular constraints they thought they might have to contend with, such as spaces available to aakonga inside and outside the PMK building. These team discussions provided opportunities for kaiako as colleagues to offer feedback and suggestions, which they each appreciated, although they did admit later they found the process somewhat time consuming.. Kaiako, however, did state that such sharing and collaboration aided their confidence, helped them to consider necessary resources, as well as to reflect on questions they might ask aakonga to support learning.

Discussing and sharing planning together meant other advantages for kaiako were also realised. In Cycle 1, kaiako worked with only one group of aakonga who had chosen to work on their task. In Cycle 2, they decided to extend the opportunity to all aakonga to engage with all three tasks. It was determined that each group of aakonga would spend a week working on each task with the kaiako in charge of that task. This collaborative way of working meant that kaiako were each able to leverage their time, with planning for paangarau learning largely reduced to one task every 3 weeks. The focus on teaching one task for 3 weeks allowed kaiako to develop their confidence and pedagogy with that task. Each kaiako therefore became an expert on their task.

2019 Phase Two: Collaboration amongst aakonga

Research identifies collaboration as ways of working together that enable aakonga to construct knowledge and engage with critical feedback that encourages them to build upon strategies and solutions developed by themselves and others (Anthony & Walshaw, 2007; Hunter et al., 2018). Of the 99 aakonga who completed the online survey in 2018, 42% appreciated being able to work with others. By mid-2019, this had increased to 52%.

The tasks presented to aakonga were deliberately designed to encourage them to debate, review, and reflect on their findings as they sought to make sense of the paangarau ideas in them. Kaiako noted that there were benefits to this collaborative approach for aakonga. Comments included the benefits of using equipment and working in mixed-ability groups:

> … the benefit of mixed ability groups is that more able aakonga helped less able … it was more collaborative. (H)

> The sharing of shapes was helpful for the children to see the pentominoes available … kids worked in pairs to keep working on shapes … the teacher was not the only one with the answer. (P)

> In finding the shapes, the younger ones could be better than the older ones. (P)

FIGURE 5. **Another view of this PMK/MLE**

KEY FINDING 2. HUARAHI AKO:
Fostering productive learning pathways

Kaiako and aakonga views on learning pathways

In this study, data analysis indicates seven elements that emerged as important findings for kaiako seeking to foster learning in this PMK. As ideas are linked, kaiako and aakonga views regarding the advantages, challenges, and affordances of this PMK regarding learning pathways are best presented thematically. Kaiako in this research sought to modify aspects of their teaching and aakonga learning in order to support the aim of increasing engagement and self-management by aakonga when learning paangarau. The findings shared below include references to all three research questions and the tasks used in Cycle 1.

Investigative tasks are beneficial but raise complexities in a PMK

Kaiako felt that the overall advantage of these tasks was that they supported aakonga to spend considerable time exploring a range of paangarau ideas in depth, especially when they were encouraged from the beginning to use equipment (sticks, rulers, tiles) to aid their exploration. While Task 2 (refer p. 7) used in this research might not be deemed "investigative"[1] (Colomb & Kennedy, 2005) by definition, it did offer learning in measurement that aakonga could draw upon when moving onto more exploratory tasks later.

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1 A mathematical investigation is open-ended with several acceptable solutions, is an exploration requiring a full period or longer to complete, and is often embedded in a focus or driving question. In addition, it will involve processes that include collaborating with peers and using multiple strategies to reach a conclusion (Colomb & Kennedy, 2005).

FIGURE 6. **One example of an investigative task used in Cycle 2**

He nui rawa ngā pouaka!!

Kua hōhā katoa a Tai me tana whānau Borrowers i ngā pouaka nei. E hiahia ana rātou i ētehi mea iti rawa mō ā rātou kai.

- Whiria tētehi pouaka. Me hanga pouaka hou mā te haurua i ngā taha katoa o tō pouaka matua.

- Me whakataurite tō pouaka hou ki te mea tuatahi.

- He aha ōu kitenga? Tuhia tētehi kōwai/whiti kia whakamāramahia. (Tāngia pea ētehi pikitia hei āwhina i tāu i kite ai).

Another advantage they noted was that the nature of Tasks 1 and 3 meant that aakonga could choose from the outset to work independently or to collaborate with their peers. The tasks also allowed for differentiated learning thereby endorsing kaiako aims of fostering self-management and engagement in a way that accommodated the interests and varying abilities of aakonga.

Task 2 regarding estimation and measurement allowed for more independent work once key ideas had been learnt.

Most aakonga appeared to respond quickly and enthusiastically to a mode of exploring paangarau ideas that demanded more involvement and responsibility of them while providing a greater number of occasions for self-management. For some aakonga, however, the investigative approach proved challenging as it was new and unfamiliar. Tamariki were accustomed to lessons that were more structured and largely teacher directed. Some aakonga therefore required greater support transitioning to a style of teaching that required them to take greater responsibility and be more active in their learning. This process involved them working with others as well as having in-depth discussions with kaiako as opportunities arose.

Kaiako also expressed concern about possible challenges for some aakonga who might not have a grasp of the paangarau knowledge required to fully engage with a task. How would these aakonga cope? When would they get an opportunity to learn and practise the ideas required of them? A comment from one kaiako was:

> I'm wondering … I worry about where the kids who need practise with whakarea (multiplication) and tango (subtraction) and taapiri (addition) … where do they get that practise … all those little skills, where do they fit in? Where do those boring skills get done? (P)

Throughout the learning sessions, kaiako did notice difficulties in paangarau that some aakonga experienced and sought to address strategy and knowledge gaps in the context of the tasks, as promoted by Te Marautanga o Aotearoa (Ministry of Education, 2008). Such noticings also contributed to dedicated follow-up sessions in Number with kaiako. Ensuring tasks can be accessed by all aakonga, or easily modified if required, is important. The use of investigative tasks was challenging and a new experience for these kaiako and their aakonga. Kaiako here are to be commended for their risk taking.

Use of appropriate equipment supports aakonga to engage positively with paangarau ideas

A fundamental pedagogical principle for supporting children's learning in paangarau is the use of equipment for modelling key concepts (Anthony & Walshaw, 2007; Swan & Marshall, 2010; Uribe-Flórez & Wilkins, 2017). While these kaiako demonstrated awareness of this principle in their teaching of Tau (Number) which was their main kaupapa for paangarau during the year, they found the use of equipment more challenging in other strands. This difference was due largely to kaiako familiarity with ideas in the Tau me te Taurangi (Number and Algebra) strand and related equipment. Consequently, the teaching and learning of ideas in other strands required more thought, time, and planning.

FIGURE 7. **A paangarau task corner**
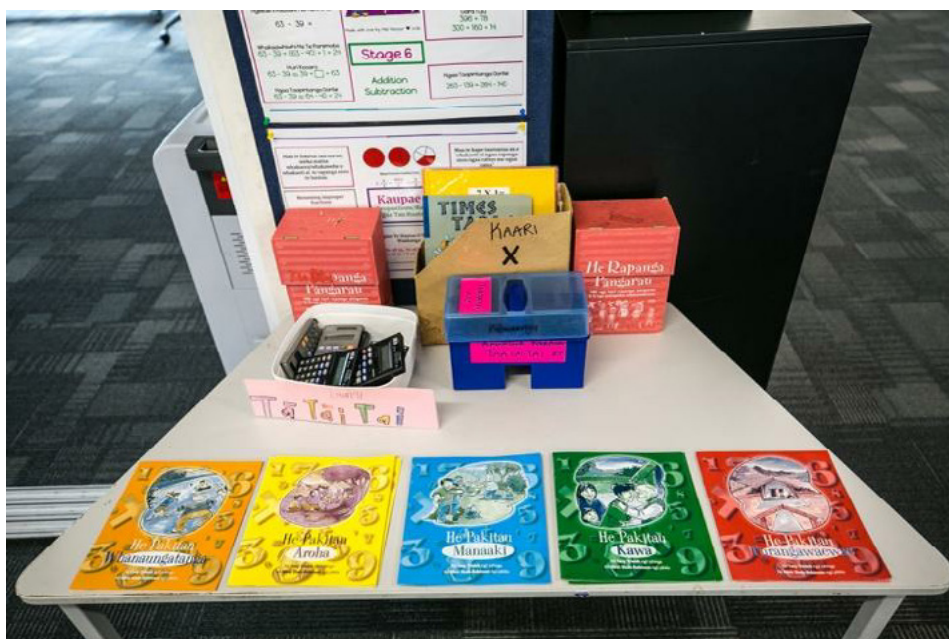
During their collaborative planning of tasks, kaiako were able to pause, discuss, and review decisions about materials that might best support the development of conceptual understanding, thereby reminding themselves of the value that specific equipment and materials can have when used appropriately. After Cycle 1 in 2019, they shared their thinking that the use of equipment was substantially beneficial for aakonga in supporting them to actively participate and understand paangarau ideas conceptually. Kaiako commented on how manipulating equipment appeared to act as a scaffold for learning and assisted aakonga to explore ideas in physical and creative ways with a degree of self-management or independent learning not obvious before the study. Their reflections included:

> He tuumahi ngahau, e waatea ai te aakonga ki te raweke ki te whakamahi whakaaro auaha ki te whakaoti rapanga. [Enjoyable tasks were presented where learners were free to manipulate (materials), to solve problems creatively.] (M)

> Ka kite ngaa tamariki ko te raweke te ako, inaa hoki, ehara maa te kaiako te akoranga e aata whaangai i ngaa waa katoa. [Children saw that using materials involved learning and also that it wasn't up to the teacher to provide the learning all of the time.] (M)

> … don't have to be perfect when cutting up the pentominoes … they needed also to move them around. (P)

Offering choice of tasks encourages engagement and self-management

At the beginning of the research, kaiako had some misgivings about offering tamariki a choice of tasks to engage with along with opportunities to better manage themselves. Comments included:

> I think that's how we all want it to be. It's just a matter of finding contexts and finding resources … some of them you give them freedom and they go … (all over the place) and then some of them are quite driven … (M)

> You wanna give them choice but you don't want to give them too much choice. (M)

> Easier to slowly change rather than go all out. (P)

> The more we just jump in and let it go, the more the kids can practise being self-directed learners and the more we can anticipate what to expect … I think we need to take some risks and maybe make some mistakes and get better. (M)

After Cycle 1 in 2019, kaiako comments indicated that giving tamariki a choice of tasks and areas to work in as well as who to work with, had a noticeable impact on their engagement and perseverance with the task they selected. Kaiako considered that being given an opportunity to choose a task seemed to appeal to aakonga. Their comments included:

> Ka muramura oo raatou kanohi … He koowhiringa! He tino pai teeraa ki a raatou. [Their faces lit up … A choice! That was really great to them.] (H)

> Having choices helped towards their independent learning and engagement … noo te mea naa raatou i whiriwhiri [… because they chose]. (M)

The 2018 online survey data indicated that 61% of aakonga identified choice of tasks (ka waatea koe ki te whiriwhiri i aau ake mahi) as important to them. In 2019, this figure increased to 70%. Data from both aakonga and kaiako identified how important choice is for aakonga. Innovative learning environments are considered to be learner focused and to emphasise valued learner outcomes. They are intended to encourage collaboration and inquiry, both for aakonga and kaiako. They are also considered to emphasise personalised learning and flexibility of support for aakonga to make choices about their learning (Education Review Office, 2018; Murphy, 2016). This research highlights the need to ensure aakonga are given the latitude to select tasks in paangarau that they wish to engage with.

Verbal introduction of tasks in te reo Maaori was useful for kaiako and some aakonga

Learning paangarau in te reo Maaori is a clear expectation in this wharekura. Kaiako were committed to this goal while seeking to support children's learning of paangarau ideas. In the PMK there was a strong reliance on verbal introductions in te reo Maaori to outline expectations of tasks. The advantage of this strategy was that it allowed kaiako to quickly gain children's attention, explain and clarify tasks, while introducing new vocabulary. Kaiako were keen to ensure that there were no barriers, such as those that could arise from reading, to aakonga engaging with the tasks. This pedagogical stance meant that they were able to respond quickly to any queries that might arise. However, a reliance on verbal introductions to tasks highlighted the demand for aakonga to listen and remember expectations of them. This strategy proved challenging for some tamariki who required more support to understand the nature of paangarau investigations as well as the expectations placed upon them as learners. One aakonga commented:

> Tuhia he tauira maa te papa maa … Kaare raatou (ngaa tamariki) e moohio me aha raatou. [Write examples on the white board … they (aakonga) don't know what they are required to do.] (Aakonga M)

The use of examples can support children's understanding of paangarau tasks. The selection of appropriate examples is linked to teacher mathematical and pedagogical content knowledge (Suffian & Rahman, 2010; Sullivan et al., 2013). For aakonga requiring clarification and assistance, it may have been helpful to use physical manipulatives, aural cues, as well as visual examples (either digital, paper based, or via a whiteboard) that modelled paangarau ideas similar to those in the tasks.

Kaiako require support to develop and review strategies for teaching and assessing mixed-ability groups in a PMK

Kaiako in this PMK were accustomed to working with ability groups. However, as part of the research they were interested in broadening and exploring the possible strengths of alternative approaches that may help increase children's engagement and self-management when learning paangarau. Mixed-ability groups emerged early in 2019 as a result of kaiako offering aakonga the mana (power) to choose which paangarau task they were keen to engage with. The composition of groups proved to be a challenge for kaiako as each group consisted of aakonga from Years 4–6. Kaiako were concerned that, while most aakonga did learn new ideas in paangarau, perhaps the more capable ones did not achieve as much as they could have. One kaiako commented:

> I think all of my kids learned something but I don't think some were extended as much as they could've been … I don't think I did enough for them … they already knew some of the stuff they were doing. (M)

Kaiako discussed a number of strategies that might be employed in Cycle 2 2019, as a result of their recognition of the importance of being able to identify and respond more quickly to aakonga who were being challenged in their learning or needing extension. Suggestions aligned with those recommended by Anthony and Walshaw (2009) ranged from asking a question, listening to an explanation, adapting a task, to arranging a group session for sharing, listening, and discussing new ideas. Kaiako also discussed the need for flexibility and patience. It seemed to them that, while tamariki were exhibiting increased engagement and gaining experience in self-management, the emergence of mixed-ability groups was the price to pay for those benefits, an outcome that posed a real dilemma for kaiako.

Managing noise for learning is important

The PMK building in this research is designed as an L shape. Apart from an internal break-out room there are no walls or full partitions. While kaiako made some use of dividers to separate spaces, these offered little barrier for sound.

In 2018, 13% of aakonga surveyed identified that their paangarau learning time would be better if others in their class were quieter. This increased slightly in 2019 to 14%. While the online survey results did not portray noise as a major issue for learning in the PMK, the focus group conversations indicated there were serious challenges regarding noise for some aakonga. In 2018, during conversations with eight aakonga, the level of noise was mentioned by only one:

> Tino noisy teeraa atu taha. [That side is really noisy.] (Aakonga T)

However, when talking with seven aakonga in 2019, it became evident that noise during the learning of paangarau time had become more of an issue for some. Comments from four of the seven tamariki in the 2019 included**:**

> He hoihoi … haaparangi. [It's noisy … shouting.] (Aakonga T)
>
> Uaua te rongo … Ka haaparangi tooku kaiako. [It's difficult to hear … My kaiako shouts.] (Aakonga A)
>
> Kaare e pai ki a au te haamama ngaa tamariki, ngaa kaiako hoki. [I don't like it when children are shouting and kaiako too.] (Aakonga J)

Findings suggest the need for a greater focus on and attention to noise reduction strategies in this PMK. Student voice highlights that it may take some adjustment to work in a space with 106 aakonga. Managing self and noise is one area for continued review.

The debate about noise in a PMK needs to be considered in relation to the literature which suggests that talking, discussing, and debating is a critical component of learning paangarau (Brown et al., 2009; Hunter et al., 2018). The authors narrate the importance for aakonga of being able to talk about, debate, and discuss paangarau concepts as a key strategy for learning, understanding, and applying paangarau ideas. The

advantages of such interactions include aakonga being able to verbalise their learning, debate their thinking while unpacking the nature of a task, and negotiating a range of possible solutions associated with problem solving in paangarau.

Assessment and reporting learning is evolving

Assessment and reporting on learning plays an important role in informing kaiako of ideas for effective teaching in the future. These practices can be an issue and were a challenge for kaiako at this PMK. When this research began in 2018, reporting against Ngaa Whanaketanga Rumaki Maaori (National Standards for MM) had recently become no longer mandatory. With the negation of Ngaa Whanaketanga Rumaki Maaori, kaiako in this PMK became unsure about their procedures for assessing and reporting on learning. As an alternative, discussions with researchers in 2019 resulted in a decision to assess against the Putanga Ako (Specific Learning Outcomes) noted in their planning for each of the Geometry/Measurement tasks. Assessments included Overall Teacher Judgement (OTJ) about the learning of specific paangarau kupu (word) as well as paangarau ideas. An example of a completed report/assessment sheet for one task is shown in Table 1 below.

TABLE 1. **He tauira aromatawai: An example of assessment**

Key:
1. Maarama puu (extensive understanding)
2. Maarama pai (strong understanding)
3. Aahua Maarama (some understanding)

Ngaa ingoa Aakonga	Putanga ako 1 Whakatau Inenga	Putanga ako 2 Maramatanga Waeina	Putanga ako 3 Reo	Kupu Hou
D	1	2	1	2
T	1	2	1	2
W	2	2	2	3
D2	2	2	3	3
W2	2	2	2	2
T2	2	2	2	2
T3	1	2	2	2
T4	1	2	2	2
T5	2	2	3	3

This study shows that the commission of a further research report that delves more critically into achievement data is imperative.

FIGURE 8. **Another internal view of this MLE/PMK**
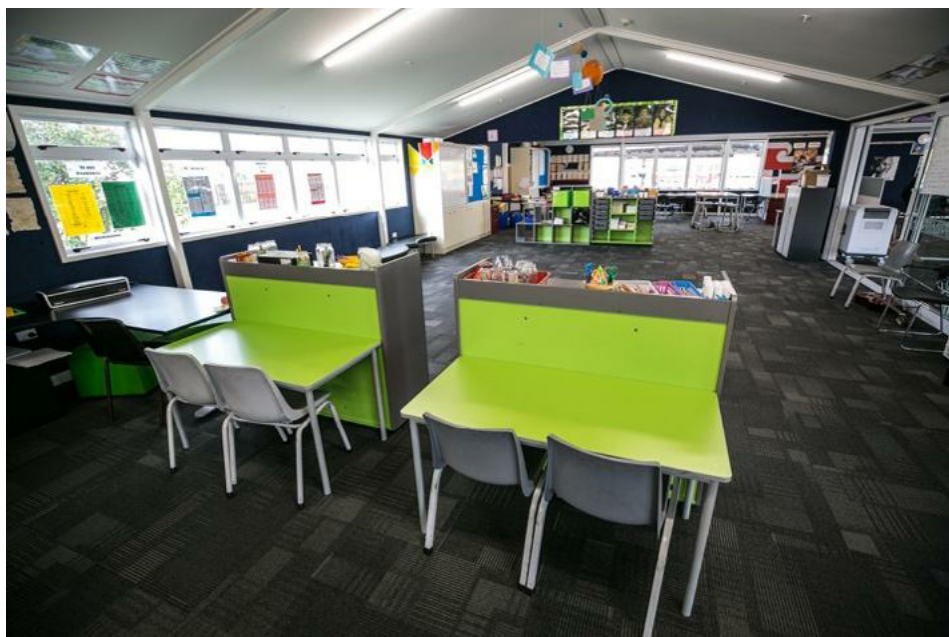
KEY FINDING 3. HANGARAU MATIHIKO:
Prioritising digital technology

Use of hangarau needs targeted support

Increased access to digital technologies is an expected feature of MLEs (Ministry of Education, 2014; OECD, 2017). One of the advantages of this PMK was the ready availability of 60 devices (chrome books and iPad) during paangarau times, although one device per student would be the ideal to support any teaching and learning situation during the day. In addition, a particular affordance in this PMK was that one kaiako took responsibility for the maintenance of the hangarau matihiko.

Kaiako stated that hangarau matihiko was an effective reward for early finishers, providing extra activities and games to support the paangarau ideas currently being taught. They felt that the drill or practice tasks that many aakonga were able to engage with on their own, or while working in small groups, were helpful for reinforcing learning. The notion of using hangarau matihiko in alternative ways—for example, a Show and Tell programme (Allen, 2017; Ingram et al., 2015)—was a challenge for these kaiako. In addition, they stated that the disadvantage of using hangarau matihiko was that most of the activities or apps available were in te reo Paakehaa/English and hence not useful for supporting the teaching and learning of the specific paangarau vocabulary essential for the communication of ideas in te reo Maaori. It became obvious also that not all tamariki had the English language skills necessary to comprehend the paangarau problems posed and the associated questions asked in these activities, which did cause frustration for some tamariki.

Akonga views from the online surveys and focus group koorero indicated an enthusiasm for using digital technology to support the learning of pangarau. Survey results in the tables below show a desire for such opportunities to significantly increase choice of tool as indicated in Table 2 below.

TABLE 2. **Aakonga views in percentages of their current use of hangarau matihiko for learning paangarau**

Year	No response	Use less than three times a week	Use three or more times a week
2018	10	51	39
2019	4	68	28

TABLE 3. **Percentages of aakonga wanting to use technology more than three times a week**

Year	Wanting to use three or more times a week
2018	68
2019	68

The results of this study highlight the need for focused planning and professional development opportunities for kaiako in MM to ensure pedagogical practice aligns with that promoted for 21st century learning in Aotearoa New Zealand (Bolstad et al., 2012; Ministry of Education, 2016a).

Implications for practice

Findings offer key ideas for us to understand and consider to strengthen teaching and learning in the continually evolving PMK arena. The implications for practice to optimise the advantages and affordances that a PMK environment offers, while addressing challenges and increasing aakonga engagement, are presented below. These implications are aligned with the three themes noted earlier which are:

- Mahi ngaatahi—Encouraging collaboration
- Huarahi ako—Fostering productive learning pathways
- Hangarau matihiko—Prioritising digital technology.

Mahi ngaatahi: Encouraging collaboration

Collaboration is a significant element for success in a PMK

Kaiako
- Effective communication for collaboration with kaiako across the whole kura is required for successful organisation, relationships, and learning for aakonga.
- Kaiako need to be able to share challenges, identify focuses for learning, and enact strategies to facilitate learning.
- A PMK environment allows for the recognition of kaiako strengths which can then be utilised to benefit all.

Aakonga
- Offering aakonga opportunities to collaborate with others was appreciated by half of the aakonga in this PMK and appeared to have a positive impact on their engagement with tasks. If collaboration is important for 21st century learning, more aakonga may need support to appreciate the significance of this element and the increased opportunities to develop the necessary thinking and skills to participate in such a way.

Huarahi ako: Fostering productive learning pathways

The incorporation of investigative tasks is worthwhile

- Facilitating the learning of paangarau through the use of investigative tasks is worthy of implementation by kaiako as such pursuits can offer aakonga significant opportunities for problem solving, sustained engagement, and development of self-management skills.

- Embracing the incorporation of 3–4-day investigative tasks was beneficial for both kaiako and aakonga as it presented them with the latitude to explore an alternative approach for developing and extending mathematical thinking. While there were only three tasks prepared for learning in each cycle, the large physical PMK environment supported a greater number of aakonga engaging with those tasks at the same time. The ability to organise such learning opportunities is an advantage afforded by the PMK environment.

Assessment is important to identify further opportunities for learning

- Assessment of learning is essential for informing kaiako of ideas for future teaching. This study shows that guidelines for assessing learning demand constant review to ensure they are appropriate for aakonga and are suitable for kaiako intent on meeting their professional obligations.

- Leadership of assessment practices in a dynamic PMK environment is vital so that consistency and reporting of learning is assured and strengthened.

Effective management of noise or discourse for productive learning is essential

- Strategies for promoting productive discussion between aakonga and the negotiation of appropriate noise levels are important in a PMK as such elements can impact on children's focus, engagement, and completion of tasks. Clear boundaries are therefore required so that the effective and fruitful talk necessary for the learning of paangarau is possible.

- Suggestions for designated quiet zones or break-out rooms where aakonga are able to work in reduced noise zones are worth investigating (Ministry of Education, 2016b; Murphy, 2016).

Different grouping of aakonga can offer increased opportunities for learning

- Offering aakonga choice in task selection is important. This modification in pedagogy, however, created a situation that caused kaiako in this study to change from ability group teaching to mixed-ability teaching. Taking risks in teaching practice, even if based on research and experiences of others, can be uncomfortable and cause anxiety. The impact of mixed-ability grouping in this PMK suggests that offering kaiako encouragement and assistance to guide and support them to develop skills necessary for teaching such groups is recommended.

Ensuring kaiako voice in the physical design of a PMK is an imperative

- When designing new PMK, the act of explicitly seeking kaiako voice on this matter indicates to them that their thinking is valued and vital for successful construction. The need to include and act upon perspectives from practitioners regarding tangible features of PMK including design of space, storage, furniture, and equipment, from the initial design phase, was highlighted by these kaiako.

Hangarau matihiko: Prioritising digital technology

Increased utilisation of hangarau matihiko is a priority

- This study shows that aakonga appreciate their current access to digital technologies available to them for learning paangarau and are keen for this to increase significantly as part of their regular learning programmes.

- While our tongikura aligns with kaiako and kura doing all they can for learners with what they know and have, this action does not preclude the Ministry of Education from fulfilling those basic requirements expected of

them by any school in Aotearoa. Such expectations include meeting the cost associated with the creation and provision of quality learning experiences that involve the use of digital technology. Successful learning of paangarau in a PMK requires the use of such technology. Anything less fails to take full advantage of the affordances that environment provides.

Implications for research

Continued research in this area is essential if we are sincere about understanding and enhancing the positive value of a PMK environment for the teaching and learning of paangarau Considerable thought and effort is required to determine and address the complex nature of such teaching and learning. This research suggests that kaiako and aakonga need to be creative, brave, and resilient to maximise the use of the advantages offered by the PMK environment.

This study focused on the experiences of kaiako and aakonga over a 2-year period. More detailed data regarding aakonga perspectives about their paangarau learning would have enhanced this study. In hindsight, the inclusion of individual interviews with aakonga more frequently may have ensured a greater capture of their voice and experiences alongside the perspectives of their kaiako. Further research in a PMK with a focus on describing and measuring aakonga progress and achievement in paangarau is also imperative, as is the exploration of any correlation between aakonga collaboration and achievement, and kaiako collaboration and aakonga achievement. The effect, if any, that aakonga and kaiako collaboration might have on aakonga progress and achievement would be interesting to pursue as well. The results of research projects such as these and others could reveal compelling data necessary for assisting us in determining the nature of future pathways for effective learning of paangarau in a PMK setting.

Concluding remarks

MM settings are now 30 years old. Their whaanau, tumuaki, and kaiako continue to review, rethink, and reshape schooling in their respective communities. PMK is one such example of MM kura growing and evolving. It is critical that research continues to capture future iterations.

Acknowledgements

FIGURE 9. **Aerial view of Te Wharekura o Raakaumangamanga**

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