EXPLORING TRAJECTORY

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WHY BLOCKS? | CLASSROOM SNAPSHOT

Two children are constructing an intricate, multi-storey block structure. Conversations abound related to equivalence and measurement, stimulated by the 1:2:4 ratios inherent in the blocks: “We’ve run out of rectangles… we can use the squares! We need two of these to make it the same as this one. Put three… no, four of these little ones here. Yep, that’s level.” One child takes an angled block and places it on the edge of the top platform. “I have an idea! I need a wheel, ” he exclaims, envisioning the angle as an inclined plane. Sourcing a wooden wheel, he places it at the top before releasing it down the slope, intently observing its movement. He quickly selects additional triangular and angled blocks, carefully lining these up on the lower levels as a pathway for the wheel as he mentally visualizes the structure, making hypotheses about how it will work before testing the wheel’s trajectory. This process requires precision in spatial skills, estimation and implicit measurement, as well as deft fine motor control.

Some of the triangular blocks are deeper than the blocks on which they rest, so as the wheel moves along them, they tip. “No, wait, we need to make it stable,” says the other child, adding rectangular blocks as supports to carefully balance the angled pieces. Throughout this iterative process of repeated experimentation, testing, evaluating results and making revisions, the children question themselves and one another, “What about something like this?” “Hmm, that won’t work. How about here?” “That’s better! Let’s see if we do this”. Through both success and failure over many attempts, the children exhibit problem solving, perseverance and focus.

They continue to work collaboratively together until they are satisfied with their solution: “Oh wait! That works! This actually works!” “I don’t know whose idea this was.” “It was both of our ideas!”

Releasing the wheel at the top of the structure now brings success, with the wheel reliably progressing from one ramp to the next as it traverses down the structure. Observing the wheel’s trajectory sparks a desire to devise a new challenge: creating a target to hit with the wheel. The subsequent exploration demonstrated evidence of systems thinking, a key element of engineering, as the children manipulated independent structures to interact with one another. Other children became inspired by this group’s work and began to explore ramps and trajectory within their own block investigations, elaborating on the pair’s original prototype in their own designs.

WHERE IS THE LEARNING?

This brief classroom snapshot reveals evidence of the myriad learning opportunities inherently afforded by wooden unit blocks through children’s active investigation and iteration. These children are propelled by innate curiosity, immersing themselves in STEM within the context of their play. Blocks provide an authentic context for exploring the physical world, imbuing a wide range of mathematical, technological and scientific ideas and relationships. Like scientists and engineers, children experiment with structures, simple machines and physics as they play with blocks and investigate mathematical concepts such as measurement, properties of shape, number, estimation, comparison, prediction, symmetry, balance, and equivalence. The precise dimensions of unit blocks give children opportunities to engage with part-whole relationships and fractions. Children's intuition, reasoning and language around spatial relationships, physics and engineering concepts are developed as they directly experience phenomena and creatively solve meaningful problems.

Playing with blocks engages natural engineering processes in which children share ideas, set goals, construct mental and verbal blueprints for a design structure, and see that design through to its completion, evaluating throughout and refining their design through iteration (Gold et al., 2020). When interacting with blocks, children are designing technology by creating something that is useful, helpful, or solves a problem (Lindeman & Anderson, 2015). Importantly, this learning occurs in a context that is enjoyable and meaningful for children, cultivating engaged, intrinsically motivated and resilient learners who have self-efficacy as well as positive attitudes towards STEM.

A detailed overview of the possibilities for STEM learning generated through children's engagement with blocks is included on pages 12 and 13. Further information about pedagogical practices and key considerations for educators and school leaders follow thereafter. These chapters are accompanied by classroom snapshots from a number of Western Australian Independent Schools, which serve as contextualised representations of key ideas. AISWA wishes to thank the schools and teachers who generously shared their classroom stories, and the children whose learning is featured throughout.

CURRICULUM CONNECTIONS

THE IMPORTANCE OF INTEGRATION

While STEM learning incorporates distinct fields of Science, Technologies, Engineering and Mathematics, it is very much an interdisciplinary approach.

> **Just as the STEM disciplines are linked together in real life, they need to be linked together in the classroom to be the most potent. Teachers can address each subject in isolation, and children will build knowledge, just as they do with other subjects. But STEM is far more meaningful and the learning is far more engaging when the disciplines are integrated and intentionally connected. Integration of the disciplines helps students see and make real-life connections. This makes STEM much more relevant and meaningful to them.**
>
> Born Selly (2017)

While STEM experiences may intentionally foreground one learning area, such as Mathematics in the example on page 14, they typically provide meaningful integration of two or more disciplines. Evidence from ACARA's '*STEM Connections*' project (2016) suggests that STEM knowledge, understanding and skills are "strengthened when the connections between learning areas are emphasised, and enriched when learning areas combine to find authentic learning opportunities for students in answer to an identified problem or in the creation of a solution." As stated by Clements et al. (2020), STEM educators strive to "make rich connections among domains while respecting the core concepts, procedures and underlying principles of each."

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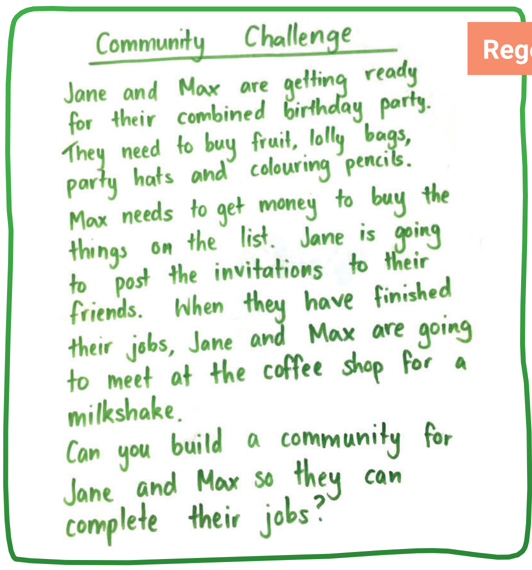
PLAYFUL LEARNING: PROVOCATIONS AND PROPOSALS

Play is imbued with evidence of children autonomously testing and stretching their capabilities and suggesting challenges for their own learning, e.g. "Let's build a tower as high as the roof." At times, however, educators will seek to intentionally nudge children's learning in certain directions, including towards curriculum intents, through inviting children's engagement with teacher-designed provocations. Provocations are responsive to children's learning and play and can take a number of forms, such as:

- Curating the **environment** in ways that encourage desired learning to flourish. For example, after noticing that children were building sprawling constructions, the educator might tape boundaries on the floor that encourage taller structures, which necessitate increasingly complex building skills and ideas. Measuring tapes could be included to stimulate measurement. If educators would like children to study movement, materials such as marbles, tubes and ramps might be added to the block space.
- Posing a **guiding question** to the children, e.g. *I wonder, how can we make our towers tall, but also strong and stable?; What causes the marble to go faster or slower?; How might you change the direction of the ball's motion at the end of the ramp?*
- Framing provocations as a **design challenge or brief** that supports problem-based learning.

Heroman (2017) suggests provocations support differentiation when they are designed to have a "low floor" (there is an easy entrance point for every child), a "high ceiling" (offering opportunities for challenge and complexity) and "wide walls" (children can explore in many different ways, bringing their own ideas, solutions and ingenuity to the experience). Design challenges, or briefs, should present a problem that is compelling enough that children care to solve it. Design briefs that involve blocks naturally incite opportunities for STEM learning, but these can be amplified towards desired learning intentions and enriched problem solving through the inclusion of design constraints. Older children are typically capable of managing more constraints and complexity than younger children (Cunningham et al., 2018) but younger learners might still be invited to build a bridge to go over this [fabric] water, but make sure there are steps so people can get onto the bridge, for example. Children themselves might also be involved in developing design briefs. Perhaps after reading Pamela Allen's book *Inside Mary Elizabeth's House* (2000), children might co-construct a design brief that outlines the essential elements in a house for Mary Elizabeth and her monster.



ORGANISING THE ENVIRONMENT

Educators' decisions and practices around temporal, physical and social environments will impact children's opportunities for STEM learning.

TIME

Adequate time for block investigations fosters more sophisticated play, problem solving, inquiry and creativity (Wellhousen & Kieff 2001; Hansel, 2015).

EDUCATORS' AUDIT: TIME

- ☐ Sufficient uninterrupted time is allocated for block investigations, ideally a minimum of 45-60 minutes (Wellhousen & Kieff, 2001).
- ☐ Constructions can be preserved as 'work in progress' to allow for children to return to their structures to improve and redesign them.
- ☐ Children have time for reflection and sharing.

EXTENDED TIME AND TEAM MEETINGS

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TIME | CLASSROOM SNAPSHOT

This block investigation spanned multiple days, supporting children's iteration and collaboration. As part of a new inquiry into weather, the children received the following design brief:

Create a house with a bedroom, kitchen, bathroom and a living room. It must have a roof that covers all rooms. The backyard needs a place to keep dry if it rains, a shady spot if it is sunny and at least three things to play on.

Groups encountered significant challenges during their first session, so the following morning started with team meetings to discuss the challenges and record a list of jobs for any amendments. Children's planning, oral language, negotiation and critical thinking were enhanced through these team meetings.