

CULTURAL PERSPECTIVES ON MULTIPLICATIVE THINKING IN MATHEMATICS

Claire POH

Charles University, Magdalény Rettigové 4, 116 39, Prague 1, Czech Republic
clairepohhs@gmail.com

ABSTRACT

This paper explores how students understand and express multiplicative relationships and patterns through both conventional representations and culturally grounded pedagogical approaches. The Goompi Model—an Indigenous framework—is examined to show how it supports learners in recognising structure, growth, and generalisation in pattern-based tasks. Drawing on a case of growing patterns, this study shows how students transition from concrete representations to algebraic expressions by engaging with visual and cultural forms. Rather than relying on solely abstract notation, students use spatial logic and culturally embedded reasoning to articulate linear relationships. This approach offers insights into the teaching of algebraic thinking and multiplicative reasoning, bridging formal mathematics with everyday meaning-making.

1 Introduction

Understanding multiplicative relationships is foundational to algebraic thinking and functional generalisation. These relationships support key mathematical ideas such as growth, scaling, and symbolic expression. While concepts like ratio, rate, and function all involve multiplicative reasoning, this paper focuses on how students perceive structure and repeated change—particularly through growing patterns that can be expressed as linear equations of the form:

$$y = mx + c.$$

This paper examines how students transition from concrete representations of change to symbolic generalisation, and how culturally responsive approaches can support this process. Specifically, the Goompi Model, an Indigenous pedagogical framework, is explored to examine whether cultural perspectives, spatial reasoning and symbolic meaning-making can be integrated to support students in constructing mathematical relationships through observation and interpretation.

2 *Theoretical Perspectives Contextualised*

Learning can be understood through different interpretative lenses, each offering unique insights into how understanding develops. The Goompi Model, grounded in Indigenous epistemologies, represents one such lens—highlighting the cultural, symbolic, and experiential dimensions of mathematical learning (Matthews, 2012). While distinct in its foundations, the Goompi approach resonates in important ways with the theories of Bruner (1966) and Vygotsky (1978). Like Bruner’s emphasis on progressive representation (enactive, iconic, symbolic) and Vygotsky’s focus on the social and cultural mediation of learning, the Goompi Model affirms that meaning-making emerges through both internal construction and external cultural contexts. Viewed together, these perspectives enrich our understanding of how students develop multiplicative reasoning through culturally embedded mathematical experiences.

Bruner (1966) proposes that learners construct knowledge by progressing through enactive (action-based), iconic (image-based), and symbolic (abstract) stages. This model informs our interpretation of how students move from visual or spatial patterns to generalised mathematical expressions such as linear equations.

Similarly, students’ engagement in collective pattern creation and discussion, allowing mathematical understanding to emerge from shared cultural experiences directly reflect Vygotsky’s (1978) theory that learning is a socially embedded process shaped by context, tools, and interaction.

In parallel, the Goompi Model offers an epistemological and pedagogical lens rooted in Indigenous perspectives. It conceptualises mathematics as a cyclical process where knowledge emerges through lived experience, is abstracted and expressed through culturally mediated symbols, and is reflected back into real-world contexts. This framework foregrounds cultural identity and symbolic meaning-making as integral to mathematical understanding.

2.1 **The Goompi Model**

The Goompi Model, developed by Matthews (2008), provides a culturally grounded framework for understanding mathematics as a dynamic and cyclical process. As illustrated in Figure 1, the model shows how learners begin with

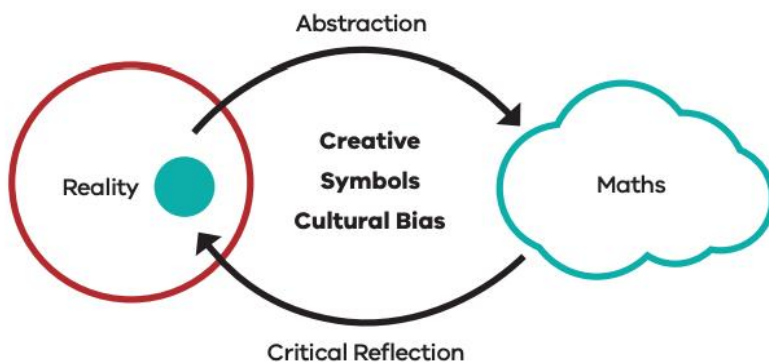


Figure 1. The Goompi Model (Matthews, 2020, p. 5)

reality—lived experiences or phenomena they wish to understand.

Through abstraction, they generate representations such as drawings, language, and symbols, which are shaped by creativity, cultural bias, and symbolic meaning. These become formalised into what we refer to as mathematics.

The cycle continues as students apply their mathematical ideas back to reality through critical reflection, allowing them to test, refine, and contextualise their understanding. This cyclical process foregrounds three key cultural elements: Creativity as self-expression; Symbols as bridges between reality and abstraction; Cultural bias as an inevitable and meaningful lens shaping how knowledge is constructed (Matthews, 2008).

In this paper, the Goompi Model is not used as a prescriptive teaching method but as a conceptual lens (Matthews, 2012) to examine how culturally embedded visual patterns can support students' development of multiplicative reasoning. The model highlights the potential of connecting formal mathematics to students' lived experiences, enriching both understanding and engagement.

2.2 Cultural Pathways to Multiplicative Thinking

The paper draws on cultural and Indigenous perspectives referring to mathematical ways of knowing that emerge from the everyday practices, worldviews, and pedagogies of diverse communities (Matthews, 2008; Ascher, 2018; Lipka et al., 2005). While multiplicative reasoning is found

dational in formal mathematics, it also emerges organically in cultural practices through practical, visual, and spatial tasks.

In Indigenous and artisanal traditions, this form of reasoning is embedded in activities such as time measurement, navigation, weaving, and art (Ascher, 2018). For example, American Indian design practices (Lipka et al., 2005), often generate shapes through diagonal or midpoint cuts along lines of symmetry, ensuring that components are proportionally related. The emphasis on symmetry, congruence, and visual balance—reflected in cultural notions such as “black and white must be in balance; one follows the other” (p. 33), —demonstrates how multiplicative thinking is deeply rooted in spatial and visual design. This alignment reveals a meaningful convergence between community-based knowledge systems (Miller & Armour, 2021) and the formal mathematics taught in schools.

The Goompi Model, developed by Indigenous educator Chris Matthews (2008), exemplifies this integration. It draws on culturally grounded ways of seeing and representing growth. The model’s spiral patterns echo recurring forms in nature (e.g., shells, storms, galaxies) that students may recognise from cultural narratives or lived experience. Its pedagogy is dialogical, participatory, and observation-driven, reflecting Indigenous teaching traditions. In this way, mathematics is not imposed on culture but emerges meaningfully from within it.

3 Research Focus and Question

This paper adopts a practice-oriented lens to analyse how growing patterns can support students’ understanding of multiplicative relationships when presented through culturally situated frameworks. In particular, it draws from documented pedagogical practices, including a linear pattern task rooted in the Indigenous Goompi Model, to explore how mathematical ideas are constructed through cultural tools and representations. Rather than presenting new empirical data, the discussion synthesises insights from existing classroom applications to explore the conceptual significance of such approaches. Accordingly, the research question guiding this paper is: *How can Indigenous pedagogical approaches, such as the Goompi Model, support students’ understanding of multiplicative relationships through growing patterns?*

4 *Conventional Introduction to Linear Relationships: The Growing Pattern Approach*

In conventional instruction, students are often introduced to linear equations through the abstract formula $y = mx + c$, a method that can feel disconnected and cognitively demanding. To ease this transition, teachers frequently use growing patterns, such as the T-block configuration shown in Figure 2 as a visual tool to help students recognise structure and derive symbolic expressions. The growing pattern approach typically involves two steps: first, students identify a number sequence by counting the number of squares in each stage of the pattern. This step is generally intuitive and accessible. However, the next step, which involves formulating a linear equation from that sequence, is often less obvious. It requires students to discern the underlying structure of change and express it algebraically, presenting a cognitive challenge that may not be immediately apparent.

From the sequence, 5, 6, 7 and 8, students are expected to derive a generalised equation, $y = x + 5$, where x represents the number of added blue blocks, and y the total number of blocks. Generating a symbolic expression from the pattern involves a significant conceptual leap. It requires students to distinguish between constant and changing components, and to express that relationship algebraically.

The visual pattern depicts a growing structure, where each figure in the sequence adds one additional unit compared to the previous figure: 5 squares in the first figure, 6 in the second, and so on. This consistent increase by one square per step reflects a linear growth pattern.

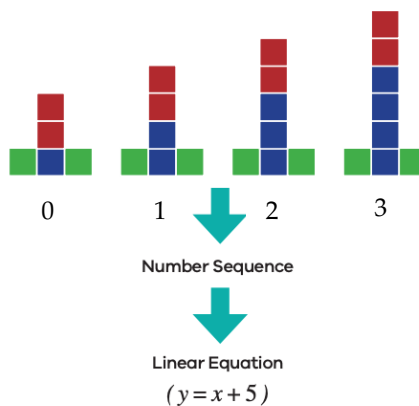


Figure 2. A typical representation of a growing pattern (Matthews, 2020, p. 6)

The equation $y = x + 5$ represents this growth algebraically, where:

- x refers to the step number, starting from 0.
- x can also be interpreted as the number of blue squares added.
- y represents the total number of squares in that step.

So, at Step 0 ($x = 0$): $y = 0 + 5 = 5$ squares

At Step 1 ($x = 1$): $y = 1 + 5 = 6$ squares

At Step 2 ($x = 2$): $y = 2 + 5 = 7$ squares

At Step 3 ($x = 3$): $y = 3 + 5 = 8$ squares.

Although the T-block pattern is designed to help students distinguish between the constant part (the part that stays unchanged) and the part that grows (represented by the multiplicative factor), it can still pose cognitive challenges. While students may grasp the additive aspect, recognising that one block is added at each stage, they often struggle to interpret this repeated addition as a multiplicative relationship. Identifying that the total number of blocks increases by a consistent factor (m) relative to the step number requires abstract thinking. This makes the transition from counting to constructing a generalised algebraic rule, $y = mx + c$, a nontrivial step for many learners.

5 *The growing pattern pedagogy using the Goompi model*

While the conventional growing pattern approach supports students' emerging understanding of linear relationships through structured visuals and colour differentiation, it remains relatively abstracted from personal or cultural meaning. The figures are helpful but arbitrary. In contrast, the Goompi Model (Matthews, 2008) situates mathematical growth within cultural forms that carry meaning—spiral patterns drawn from Indigenous knowledge systems. This model encourages students not only to observe growth but to interpret it through personal perspective, spatial reasoning, and narrative. In doing so, it has the potential to deepen engagement and make the structure of a linear relationship more intuitive, especially for students who benefit from contextual, story-based, or visual-spatial learning. The following section explores how this model supports the same core algebraic concepts—constancy and change—through a culturally grounded representation. Matthews demonstrates how the Goompi model can be applied to enhance the teaching and learning of growing patterns through 3 stages of representation, as shown in Figures 3,4 and 5.

Figure 3 introduces the first stage of Matthew's growing pattern activity

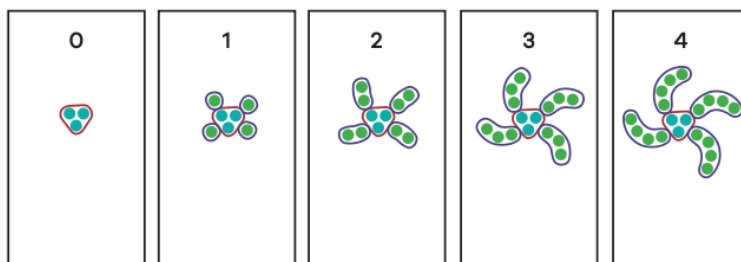


Figure 3. First stage of growing pattern pedagogy using the Goompi Model (Matthews, 2020, p.7)

using the Goompi Model. In this stage, students collaboratively construct a spiral pattern over five days on a large sheet of butcher's paper. The activity is designed to help them connect the visual structure of a growing pattern with the abstract structure of a linear equation.

The pattern begins on Day 0 with a triangular red outline surrounding three blue dots at the centre, representing the constant part of the pattern. Each subsequent day, green dots are added in a regular, outward-spreading spiral. The rule governing this growth is that four green dots are added per day, arranged into a new curved arm that extends from the central core. These arms increase in length and number, forming a swirling spiral shape over time.

The teacher facilitates this process, modelling how to extend the pattern and prompting students to follow the rule: for each new day, add four new green dots, one per arm, so that each arm grows symmetrically. Students may associate these visual forms with familiar natural spirals such as hurricanes, galaxies, or flowers, which helps reinforce the cultural grounding of the activity. To support mathematical understanding, the teacher prompts students to distinguish between the parts that remain constant and those that grow. The constant part (3 blue dots) is marked in red, while the growing green dots are colour-coded to highlight the additive progression.

The use of butcher's paper serves a specific pedagogical purpose: it offers a large, communal workspace that allows the whole class to participate in and reflect on the pattern-building process over multiple days. Its expansive size enables the growing spiral to remain visible and physically accessible throughout the unit, supporting both spatial reasoning and collaborative dialogue.

In the second stage (Figure 4), students begin quantifying the visual pattern. They calculate the total number of dots (S) on each day by summing the constant part (always 3 dots) with the growing part — which increases by 4 dots per day. On Day 1, for example, students observe 3 constant dots + 4 new dots = 7 dots. This progression continues across Days 2 to 4:

$$\text{Day 2: } 3 + 8 = 11$$

$$\text{Day 3: } 3 + 12 = 15$$

$$\text{Day 4: } 3 + 16 = 19$$

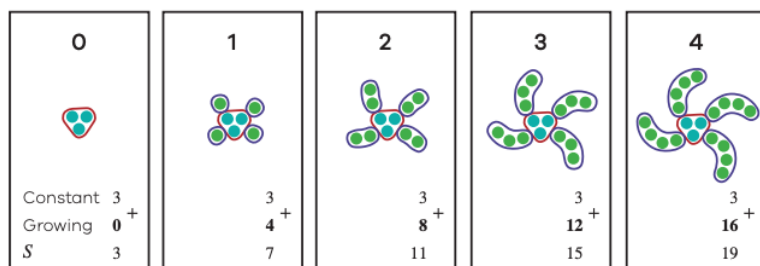


Figure 4. Second stage of growing pattern pedagogy using the Goompi Model (Matthews, 2020, p. 7)

This helps students shift from qualitative pattern recognition to quantitative analysis. They are then asked to make predictions, such as estimating how many dots will appear on Day 365. In doing so, they begin identifying the underlying structure of the pattern.

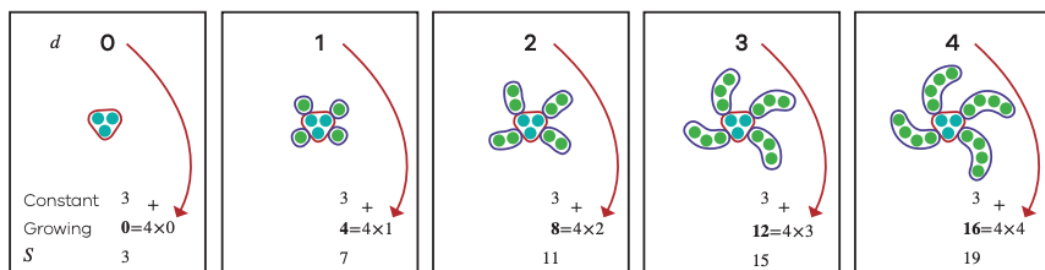


Figure 5. Third stage of growing pattern pedagogy using the Goompi Model (Matthews, 2020, p. 8)

In the final stage, the focus shifts to developing a mathematical relationship between the spiral's size (S) and the number of days (d) by analysing the

constant and growing parts individually. As illustrated in Figure 5, students observe that the total number of dots at each step is composed of a constant core (always 3 dots) and a growing component that increases by 4 dots per day. This leads to the generalisation:

$$S = 4 \times d + 3,$$

where S is the total number of dots and d is the number of days.

This equation captures the structure of the pattern: for every day that passes, 4 additional dots are added to a constant core of 3 dots, resulting in the general form $S = 4d + 3$. Starting the pattern at Day 0 highlights the presence of this existing structure before any growth occurs, making the linear relationship more explicit. It ensures that when $d = 0$, $S = 3$, allowing students to clearly connect the equation to the visual pattern and understand how each part—the constant and the growing—contributes to the overall structure. To reinforce this understanding, the teacher challenges students to interpret alternative rules (e.g., $S = 5d + 2$) and construct new patterns accordingly, encouraging them to explore how different constants and rates of growth affect the structure.

6 *Conceptual Insights and Discussion*

Growing patterns follow a consistent rule, such as adding four dots at each step, which can be expressed using the equation $S = 4d + 3$. This linear form helps students transition from recognising visual patterns to representing them symbolically. Understanding multiplicative relationships builds students' ability to generalise, predict, and model real-world scenarios. Recognising how quantities scale supports critical thinking, especially when students use multipliers to project future values.

The Goompi Model frames linear growth through a culturally responsive lens, embedding mathematical ideas in a pattern within natural forms and familiar designs. By grounding abstract concepts like linearity and multiplicative relationships in visual and experiential learning, students can begin to see mathematics as both universal in structure and diverse in expression.

The relationship represented by the equation $S = 4d + 3$ exemplifies a multiplicative structure, where a consistent rate of increase (4 new elements per day) is added to a fixed starting value. This mirrors the format $y = mx + c$, first introduced through the T-block growing pattern. While the T-blocks offer a

more schematic or algebraic representation, the Goompi approach leads students to construct the same multiplicative structure through observation, spatial reasoning, and cultural narrative.

In the Goompi model, students are not simply applying a given rule; they construct the rule themselves based on observation, spatial reasoning, and collective discussion. This contrast reveals the approach's potential to deepen student's understanding.

7 Conclusion

This paper examined how the Goompi model supports students in constructing mathematical rules through observation and spatial reasoning. It exemplifies how learning can unfold through culturally grounded representations, offering students intuitive access to complex concepts like linear equations. This reflects a constructivist perspective, drawing from Vygotsky's emphasis on social and cultural mediation and Bruner's theory of cognitive representation, where learners move from action-based experiences to abstract symbols. These perspectives affirm that mathematical thinking can evolve through multiple cultural and cognitive pathways.

REFERENCES

- Ascher, M. (2018). *Mathematics elsewhere: An exploration of ideas across cultures*.
- Bruner, J., S. (1966). *Toward A Theory of Instruction*. Oxford University Press.
- Lipka, J., Sharp, N., Brenner, B., Yanez, E., & Sharp, F. (2005). The Relevance of Culturally Based Curriculum and Instruction: The Case of Nancy Sharp. *Journal of American Indian Education* 44(3), 31–54.
- Matthews, C. (2008) Stories and Symbols: Maths as storytelling. *Professional Voices*, 6(3), 45–50.
- Matthews, C. (2012)). Maths as Storytelling. In K. Price (Ed.), *Aboriginal and Torres Strait Islander Education. An Introduction for the teaching profession* (pp. 99–112). Cambridge University Press
- Matthews, C. (2020) Teaching Mathematics from a Cultural Perspective. *Issues in the teaching of mathematics*. Victoria State Government, Department of Education and Training.

Miller, J., & Armour, D. (2021). Supporting successful outcomes in mathematics for Aboriginal and Torres Strait Islander students: a systematic review. *Asia-Pacific Journal of Teacher Education*, 49(1), 61–77.

<https://doi.org/10.1080/1359866X.2019.1698711>

Vygotsky, L., S. (1978). *Mind in Society*. Harvard University Press.

