NCCA

An Introduction to Mathematical Modeling

Introduction

Mathematical modeling involves using mathematics to describe a problem-context and determine meaningful solutions to the problem. It is important for children's learning for two main reasons. Firstly, as children engage in mathematical modeling of problems, they take part in an active, meaning-making process, where they organise and make sense of their informal mathematical knowledge and experiences and select ways to communicate their mathematical ideas. This process, where children build on prior understandings to construct new knowledge, aligns strongly with how research describes the learning of mathematics. Secondly, within mathematics, mathematical modeling is a process by which mathematicians develop and use mathematical tools to understand, represent, and solve real-world problems. Facilitating children's exploration of problems with realistic contexts showcases mathematics as a tool which can make sense of the world, and offers opportunities for investigation of interdisciplinary problems which cultivate the skills likely to be needed in future careers.

Mathematical modeling as a pedagogical approach

In mathematics, a model is a quantitative or spatial system that can be used in particular ways (Dooley et al., 2014). As a pedagogical approach, mathematical modeling emphasises children's own ideas and their selection of representations, and how they communicate their mathematical thinking about problems. They may represent their ideas in a variety of ways including actions, spoken language, concrete materials, diagrams/pictures, symbols or written words.

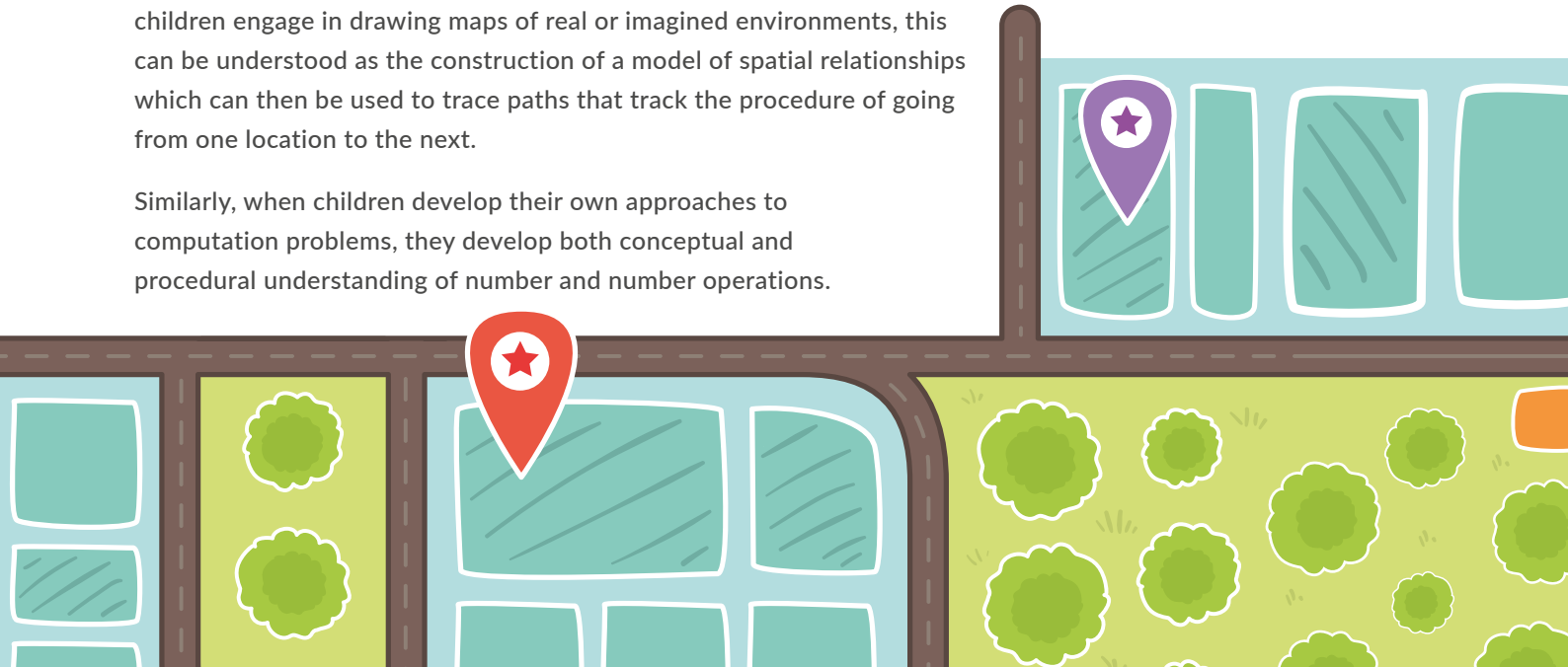
Physical models

There are a number of typical classroom artefacts that can support mathematical modeling in the classroom. For example, a hundred square displays relationships between numbers but can also be used to support calculations. Other common physical models for the teaching of Number include ten frames, number lines, fraction walls, Base ten and other concrete materials.

Conceptual and procedural models

When children are supported to develop their own models of problems, there will also be conceptual and procedural components. On a conceptual level, a model describes how elements of a system or situation relate to each other. A model may also have accompanying procedures for accomplishing goals. For example, when children engage in drawing maps of real or imagined environments, this can be understood as the construction of a model of spatial relationships which can then be used to trace paths that track the procedure of going from one location to the next.

Similarly, when children develop their own approaches to computation problems, they develop both conceptual and procedural understanding of number and number operations.



As an approach to teaching, mathematical modeling emphasises children's modeling of mathematical ideas. It is quite different from teacher modelling of mathematical concepts, where a teacher might use concrete materials, diagrams or other resources to demonstrate mathematical ideas.

Mathematical modeling is relevant to all strands of the mathematics curriculum. For example, building and understanding models of problem-situations is central to activities in Data. Similarly, mathematical modeling can be seen in Algebra activities which involve the identification and description of relationships and structure. There are also many possibilities for modeling problems arising from everyday situations or drawn from other curricular areas.

Mathematical modeling should be understood as an approach to teaching that will inform all mathematics lessons rather than a standalone activity that children will do now and again.

Children's Mathematical Modeling

Mathematical modeling is a cyclical process where children move from real-life considerations to mathematics and back again, evaluating, refining and improving the models they generate.

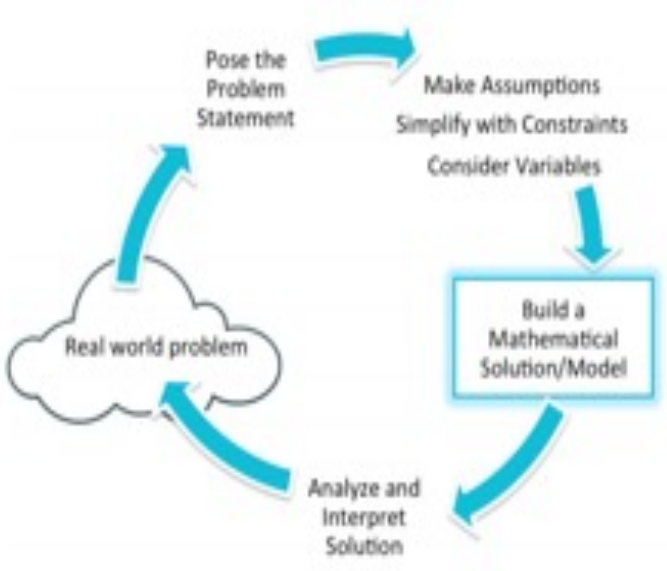


Figure 1: Mathematical Modeling process from Suh and Seshaiyer (2017)

Children may wonder about different aspects of problem-situations. Having them pose problems and refine their questions or problem statements is an important first step. Depending on the complexity of the initial problem, it may be necessary to simplify and make assumptions as problem-solving approaches are generated.

For example, children might be challenged to plan for a class party. In this context, a suitable problem statement might be 'What food should we buy for the party?' As children think through this situation, they may decide to assume, for example, that everyone will be present and that everyone should get the same amount of food. Some children may decide to simplify the situation and decide on constraints, such as an agreed budget and everyone receiving one glass of a drink and one treat. Other children may plan for more complexity, e.g., one healthy snack, one treat and one drink with the option of a refill. Children will also identify item costs as key variables, perhaps there are special offers on treats that adds complexity to the modeling.

With this understanding of the context, children will then work mathematically to find solutions. They will check if the solutions generated fit with the real-world scenario, and will cycle through the process again if necessary to refine their models to better suit the problem-situation. Children rarely move smoothly through these phases. Instead, they may move between mathematical and real-life considerations as they investigate and formulate ideas and engage in mathematical modeling with varying degrees of sophistication. In cases where the initial problem is less complex, less time may be spent on idenfication of assumptions, variables, and constraints. The cyclical nature of mathematical modeling is still important in these cases though and children should always be encouraged to evaluate and refine their models and ways of working.

As in the example discussed above, modeling activities are essentially inclusive because multiple solution methods on different levels are possible. Modeling a problem-situation with actions, manipulatives or drawings is especially useful for for younger children, or children with specific educational needs. For example, in the context of the class party described above, younger children may focus on a question that can be explored in a hands-on manner, such as, how many bottles of juice should we buy so that each person can have one cup of juice?

Resources

Integrated STEM activities focused on global citizenship issues with potential for mathematical modeling are available at https://practicalaction.org/stem/

www.Maths4All.ie

References

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