# UNIVERSITY OF ALBERTA

# Mathematical Modelling for Sustainable Development in Mathematics Teacher Education

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## Study Context

The Organization for Economic Cooperation and Development's (OECD) Sustainable Development Goals (SDG) include the need to ensure inclusive and equitable education for all learners and the role of sustainable development in teacher education is listed as a key achievement indicator for this goal. One critically important aspect of this in mathematics education is captured under the term *mathematical modeling*, which involves representing real-world phenomena with the tools of mathematics. The aim of our project was to determine:

  (1) how mathematical modeling is currently taken up in pre-service teacher education;
  (2) the extent to which it attends to the OECD's Sustainable Development Goals; and
  (3) what we can do to support mathematical modeling for sustainable development in teacher and teacher educator practice.

## Outcome 1

**Question: How mathematical modeling is currently taken up in pre-service teacher education?**

**Context:** To assess how mathematical modeling is currently taken up in pre-service teacher education we conducted a literature review. In a related study, Markle and McGarvey (2024) conducted a scoping review of research on mathematics task design in teacher education. Of the 122 studies included in that review, 7 were focused on MM, and these were included in our review here.

**Results and Implications:**
- All but one of the studies were in a secondary school context, suggesting a need for more research on MM in teacher education at the elementary level
- Using Markle and McGarvey's (2024) Task Design Action framework, the majority of these studies focused on *developing* tasks (e.g., creating math tasks from a pre-given context), suggesting a need to focus on other pedagogical aspects, such as how to select, sequence, and evaluate good MMPs
- Only a single study meaningfully addressed sustainable development issues (Villareal et al. (2018)

## Outcome 2

**Question: The extent to which mathematical modeling in pre-service attends to the OECD's Sustainable Development Goals**

We conducted a literature review and added another 5 studies focused on mathematical modelling and conducted a content analysis at the task level. Specifically, we sought to identify tasks that explicitly and comprehensively attended to at least one SDG, tasks that at least topically addressed a sustainable development context, and tasks that could be modified to do so. Table 1 depicts the number of tasks that met our criteria.

| Relevance to SDGs | Number of tasks |
|---|---|
| No relevance to SDG | 10 |
| Potential to address SDGs with modification to the task | 5 |
| Topically addresses SDGs | 5 |
| Explicitly/ comprehensively addresses one or some SDGs | 7 |

Table 1. The number of modeling tasks found in literature according to their relevance to Sustainable Development Goals(SDGs)

## Outcome 3

**Question: What we can do to support mathematical modeling for sustainable development in teacher and teacher educator practice.**

**Context:** To assess how to support mathematical modeling for sustainable development in teacher and teacher educator practice we started by analyzing the role of the teacher in the modeling cycle. Followed by suggestions to integrate sustainable development in the modeling process.

Figure 3 offers a modeling schema for integration of sustainable development directly into the modeling process.

1) **Problem Context - Select the real-world phenomena that is to be modeled through the problem.** Context selection may immediately prompt 3b given explicit relevance to sustainable development or may take some modification to address sustainable development. This is indicated by the dashed arrow.
2) Object(s) of Learning - Identify the mathematical processes and competencies used in the modeling problem and ensure alignment with learning goals.
3a) Task Design - Assess the student's current level of understanding and craft a problem that encourages collaborative participation in the modeling process.
3b) **Model-Eliciting Activity Oriented by Sustainable Development - Ensure the modeling problem challenges students to critically think about sustainable development.**
4) Mathematical Model(s) - Students will mathematicize the given MEA.
5) Model Output(s) - students will create a model to represent the given problem
6) Implications for Sustainable Development - Students will relate the model output(s) to its implication on the real world, specifically sustainable development.

**Key Takeaways:**
- Area 1 and 3b in figure three can be very close together if the problem context has explicit relevance to one or more SDGs. They can also be far apart if the problem context has no relevance to SDGs or needs to be modified. This relativity is indicated by a dashed arrow in the figure.
- This is a cyclical process and teachers should constantly use student work and feedback to improve areas 2, 3a, and 3b in Figure 3.
- Teachers should use formative feedback to assess modeling competencies during the modeling process and mathematical accuracy in the model output.

## Mathematical Modeling and SDGs

**Mathematical Modeling**
**What is Mathematical Modeling?**
Mathematical modeling is the process of representing real-world phenomena using mathematical methods and frameworks. MMPs are begun with a real world problem which is first constructed into a situational model then simplified into a real world problem which is then mathematicised into a mathematical model (Blum, 2015). Mathematical results are then obtained by working mathematically and results are then interpreted in how they relate to the real world (Blum, 2015).

> **An Example:** While on vacation at a resort, you notice that the souvenirs in the hotel gift shop are very expensive. A magnet costs $18.99, but a local lets you know that they sell the same magnet at a close by mall for $15.99. Is it worthwhile to drive to the mall to buy the magnet there?

**Sustainable Development Goals**
SDGs are a part of the 2030 Agenda for Sustainable Development designed to direct global efforts to address the most critical issues of today. This includes the need to ensure inclusive and equitable education for all learners. This not only entails removing socioeconomic barriers to access, which include income inequality, racial discrimination, and gender bias, but also ensuring that education itself is in service of sustainable development.

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**Examples of Sustainable Development Goals**

- **Goal 2 - Zero Hunger:** End hunger, achieve food security and improved nutrition and promote sustainable agriculture
- **Goal 6 - Clean water and Sanitation:** Ensure availability and sustainable management of water and sanitation for all.
- **Goal 11 - Sustainable Cities and Communities:** Make cities and human settlements inclusive, safe, resilient and sustainable.
- **Goal 12 - Responsible Consumption and Production:** Ensure sustainable consumption and production patterns

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Figure 1. Examples of sustainable development goals as set by the Organization for Economic Cooperation and Development.
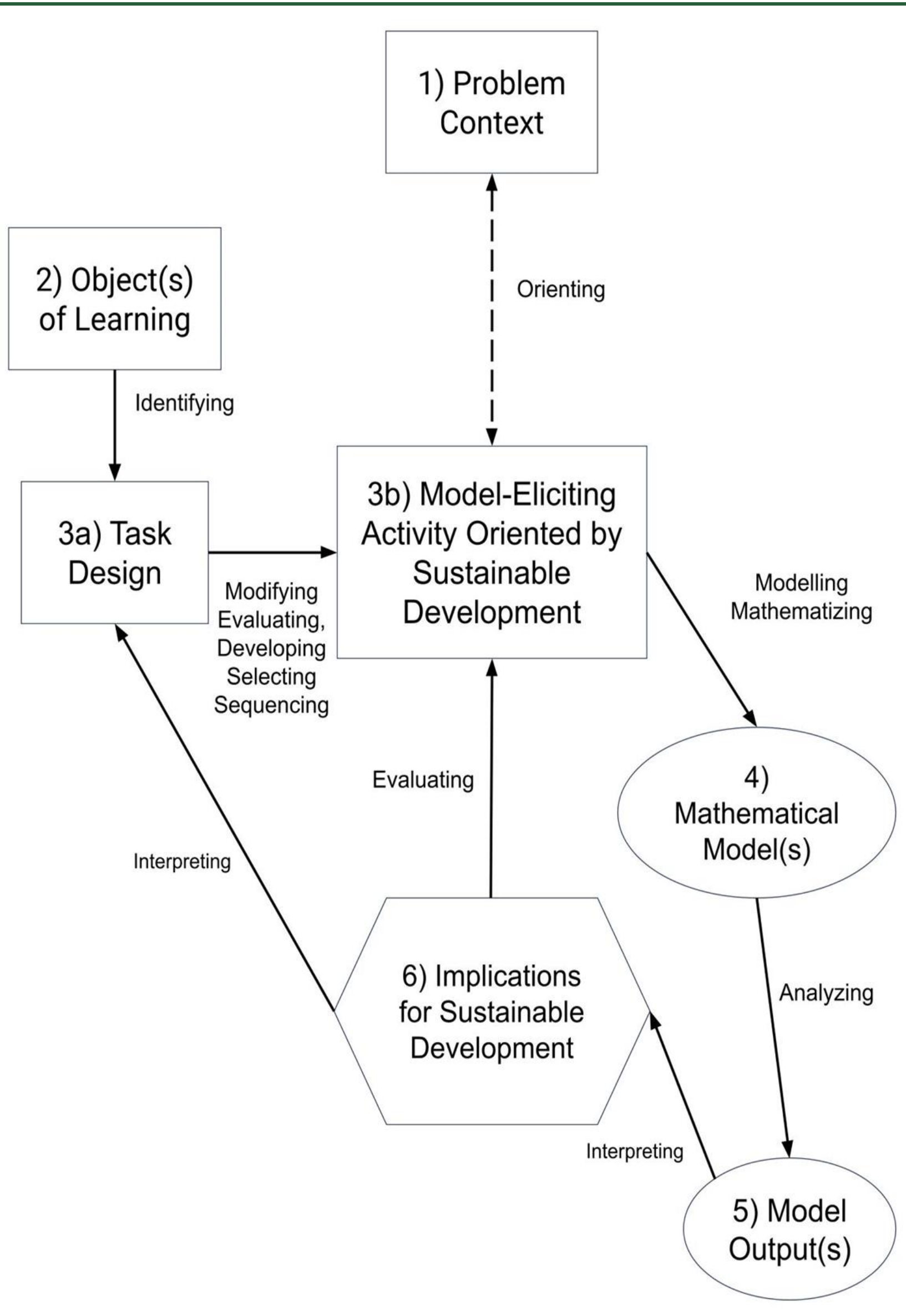


Figure 2. A modeling schema for centralizing sustainable development in the modeling process.

**QR Code**