

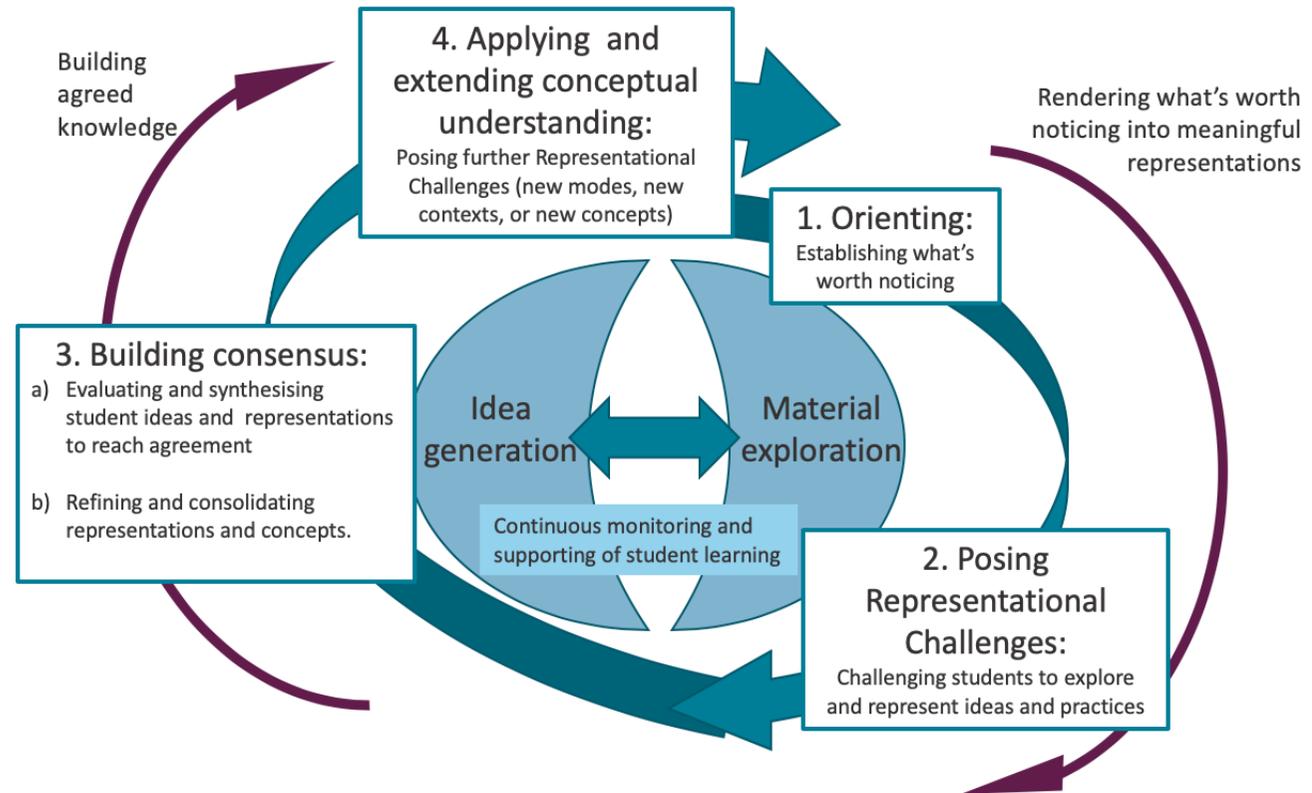
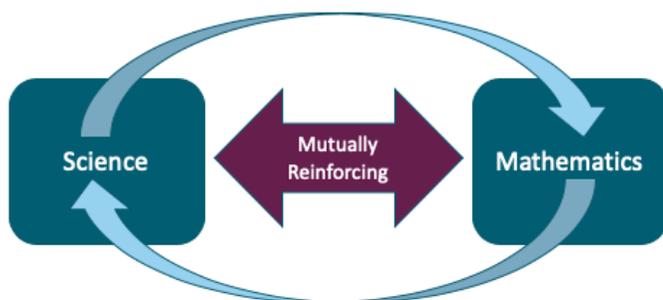
## Interdisciplinary Mathematics and Science (IMS) Learning

IMS aims to enrich learning through two interconnected principles, which are key to the nature of the unit design and the pedagogy. The first principle concerns a focus on students constructing, evaluating, and refining multimodal representations, enacted through a four-stage IMS pedagogical model. The second principle concerns interdisciplinarity: the relation between science and mathematics. The project can be found at <https://imslearning.org/>

Below we describe the key features of the approach.

### Student constructed representations

The teaching and learning sequences follow a guided inquiry pedagogy that focuses on students constructing, evaluating, refining, and extending multimodal representations. This is a literacy focus built on the insight that learning in both science and mathematics involves students being inducted into the representational practices that underpin explanation and problem solving. Representations diagrams, models, equations, graphs and tables, and symbols as well as written text. The approach involves a number of stages through which the teacher guides student learning. These stages, although distinct, often cycle and repeat within and across lessons. The model (to the right) showing these stages has been developed as an outcome of the IMS research.



### Interdisciplinarity

In the teaching and learning sequences, the mathematics and science activities are built around interrelated concepts, with the principle that the learning in each subject enriches learning in the other. For instance, measuring, graphical work and data modeling generally are freshly developed in science contexts in ways that raise questions and promote deeper knowledge in science, and the science context raises questions that can be further explored mathematically.

## Stages of the IMS Pedagogical Model

**Orienting:** Teachers pose questions, explore students' ideas and orient them to the learning focus by a variety of means such as asking for predictions, questioning what they have noticed, asking for ideas about what could be measured, and eliciting prior knowledge. This provides a way to focus students' attention on what is worth noticing about the school environment, or about data sets for instance, and could be interesting to explore.

**Posing representational challenges:** Students are challenged to explore and represent their ideas and practices, for instance they may be challenged to represent the movement of their shadow over a day, involving decisions about what to measure and how to represent patterns in length, and angle, or to use particle representations to predict, investigate and explain why a saucer of water evaporates more quickly in warm, or windy places.

**Building consensus:** This involves two stages. First, using the student ideas and representations to compare, evaluate and then synthesise these to reach agreement about which aspects of these effectively show patterns in data, or suggest explanations. Second, these ideas are refined by students, and consolidated to establish a shared understanding of the concept and associated representations. In this process students develop knowledge of the role of representational work in learning.

**Applying and extending conceptual understanding:** Students are given new representational challenges to extend their new knowledge and practices in related situations, or further concepts are introduced through representational tasks, to repeat the cycle.

In these stages the teacher is constantly monitoring and responding to students' representations and ideas. The approach can be seen as 'assessment as learning'. The focus on student production has been found to allow the teacher significant insights into student thinking. The art of teaching in this way involves setting appropriate tasks, preparing students strategically through questioning and challenges, and guiding their work to reach consensus about the key ideas and their representations. The sequences all involve a close association of material exploration, and the generation of ideas.

These stages have much in common with the 5Es that underpin Primary Connections (PC). The stages line up as Orienting = Engage, Posing Representational Challenges = Explore, Building Consensus = Explain; and Applying and Extending Conceptual Understanding = Elaborate. The 'Evaluate' stage appears in the IMS pedagogy as a continuous process of monitoring and formative assessment (assessment 'for' and 'as' learning) throughout the stages. Most sequences have a summative evaluative task, but this sits outside the cycle. Distinct from the 5Es, the IMS stages are explicitly focused on representations as central to learning (consistent with the PC focus on literacy), and structured to lead from noticing what is of interest to investigate, through the generation of representations, to generating class agreement on key concepts as systems of representations and representational practices.

The teaching and learning sequences follow these stages explicitly, but they cycle in different ways, in different lessons and in different topics. In some lessons there are more than one cycle, or even interweaving cycles for science and mathematics. In other cases, a cycle is spread over a number of lessons. Sometimes, activities have more than one role, such as an extension representational challenge acting as an orientation into a further concept. Nevertheless, we believe the movement from opening up what is noticed, to exploration and representation construction, to evaluating and building consensus, is a fundamental and powerful aspect of effective teaching and learning. Tasks in the sequences are designed to be approachable at a range of levels. This, together with teacher open questioning and targeted scaffolding, enables [differentiation](#) of the learning.

## Supporting differentiation of learning in the IMS learning design

In the IMS learning sequences the student- guided inquiry design enables diverse student learning needs to be responded to within the regular classroom. The open learning tasks are designed flexibly to enable students to work at their own level, and at their own pace, to develop their understanding and skills in a variety of ways. Variation in student responses offers a resource for promoting, encouraging and refining learning as students demonstrate, in different ways, what they know and understand. With teacher support, students learn from each others' ideas and productions. The focus on student-constructed representations, and open questioning and discussion, enables the teacher to monitor individual students' understandings and cater for their learning needs over time.

### **Features of the learning sequences that enable embedded and teacher-supported differentiation**

There are three distinct aspects of the IMS pedagogy that enable differentiation.

**Open questioning, guided inquiry and open tasks** provide the teacher with insight into individual student learning and understanding that:

- a) enables teacher decisions for on-the-spot feedback, and individualised monitoring and support of student learning through targeted learning adjustments, scaffolding, and extension challenges.  
*"Giving them (students) more freedom is a good approach because they're more capable than I thought they would be, but they still needed the support as well. So, giving students the initial freedom to do whatever they thought they could do and then helping them from that... "*
- b) enables support for students to navigate tasks with multiple entry points, solution pathways and outcome possibilities, whilst negating possible student stigmatisation from the withdrawal from their peer group, or students assigned a different task.  
*"the fact that they are open-ended so they (the students) can come to a solution in a variety of different ways. There was not one student where I had to really modify an activity for, they could participate in the activity, they could all have success in the activity but they all got something from it and because it was open-ended..."*
- c) enables the development of creative and critical thinking skills, and higher-order thinking, as student responses are not limited  
*"...I always found everything was just deeper level thinking"*

**Peer learning, collaborative learning and student voice** increases student engagement as students learn from and with their peer group.

Students learn collaboratively as a whole class and in mixed ability peer groups. Student are encouraged to share ideas, co-construct investigations, designs, data and representations. Through purposeful guided reflection, targeted scaffolding, prompts and extension challenges, students engage in comparative discussions and review of peer representations (e.g. graphical representations) to build their understandings.

*"...we were able to cater for everyone without making it obvious to them that we had to modify the activities, which I think is really important for their confidence and self-esteem and learning too".*

*"...coming from their peers and it's quite interesting because when they actually get feedback from their peers as well I find that they really do put it into practice a lot quicker, it's quite interesting, as opposed to coming from the teacher all the time, it's coming from someone different. That has been a really interesting pick up that we have found..."*

**Multimodal representational challenges** cater for diverse learner needs and provide differentiated insight into students' conceptions.

Teachers have identified that a focus on multimodal representation enhances learning for students with language difficulties, who are English Second Language (ESL), and/or have literacy support needs, since they are not so constrained by their language skills. Access to multiple modes reduces the effects

of language demands as barriers to learning. Students' multimodal representations provide teachers with insight into individual students' knowledge, skills and learning needs.

*"...this has been really interesting, seeing children that don't speak up as often really come up with some really insightful representations. I mean, they're a lot further ahead than what I thought".*

*"show me what you know through your drawings' and often that speaks volumes because children find it difficult to articulate at the time. They might understand more than what they are conveying... But they are actually showing me so much of their knowledge through their diagrams.*