EMPOWER

NATIONAL REPORT ON TEACHERS' NEEDS AND CURRENT TEACHING PRACTICES FOR MODELING-BASED LEARNING

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EMPOWER
Empowering Teachers for Science Learning Through Modelling-Based Approaches

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Erasmus+ Project EMPOWER

EMPOWERING TEACHERS FOR SCIENCE LEARNING THROUGH MODELLING-BASED APPROACHES

Project-Team of the Workpackage (alphabetical order)
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1 Introduction

The Spanish education system is highly decentralised, with primary responsibility for curriculum development and educational implementation held by the Autonomous Communities. Within this framework, Catalonia constitutes one of the most relevant regions, being the second Autonomous Community in terms of population and having its own co-official language, Catalan, which is the main language of instruction in schools.
At the national level, the current curricular framework for compulsory education was reformed in 2022. This reform established a competence-based approach that structures learning around competences and core knowledge areas (sabers), with the aim of promoting transferable learning, critical thinking, and student agency across all subject areas. While this reform explicitly promotes inquiry-oriented and active learning approaches, it does not place an explicit emphasis on Modeling-Based Learning (MbL) as a specific pedagogical framework. References to models or modeling remain implicit and are not systematically developed within the curriculum guidelines.

Despite regional adaptations, the overall structure of science-related learning in primary education is highly comparable across Autonomous Communities, particularly with respect to its competence-based organisation and broad curricular aims. In this report, the Catalan context is examined as a case study within the Spanish education system. While the analysis focuses on curricular, institutional, and professional features specific to Catalonia, the strong structural similarities across regions support the relevance and potential transferability of the findings to other parts of Spain, especially in relation to primary science education and the role of Modeling-Based Learning within competence-based curricula.

2 Educational Context

In Catalonia, science education in primary school (ages 6–12) is primarily addressed through the subject Knowledge of the Natural, Social and Cultural Environment (*Coneixement del Medi Natural, Social i Cultural*). This subject spans the entire primary stage and integrates learning related to natural sciences with social and cultural perspectives, rather than treating science as a separate, disciplinary subject.

Coneixement del Medi is organised around broad thematic domains and learning situations that address natural phenomena, living systems, Earth and environmental processes, and human interactions with the natural and social world. Learning is expected to develop through the exploration of relevant questions, problems, and situations connected to pupils' experiences, encouraging them to observe, investigate, and interpret the world around them.

The subject places strong emphasis on active and participatory learning processes. Classroom practices typically involve discussion, exploration, inquiry activities, and the use of different forms of representation to support understanding. Pupils are encouraged to express their initial ideas, construct explanations, and progressively refine their thinking through engagement with evidence and dialogue. In this sense, learning is conceived as a gradual process of sense-making rather than the transmission of predefined scientific knowledge.

Although *Coneixement del Medi* provides a curricular space that is potentially well aligned with Modeling-Based Learning, the curriculum **does not explicitly frame modeling as a central instructional practice**. As a result, the presence and depth of modeling-oriented activities depend largely on teachers' interpretations of the curriculum and their pedagogical choices. Modeling-related practices—such as creating representations, explaining phenomena, or analyzing systems—may be present, but they are not systematically foregrounded or developed as an explicit learning goal.

An additional contextual factor is the profile of primary school teachers. In Catalonia, as in most of Spain, primary teachers are generalists rather than subject specialists. They are responsible for teaching multiple areas of the curriculum, including science, language, and mathematics. As a consequence, **science is often perceived as a demanding or distant subject**, particularly by teachers who do not have a strong background or confidence in scientific content and practices. This generalist profile can influence how science is taught and may affect the adoption of demanding pedagogical approaches such as Modeling-Based Learning, which require sustained engagement with scientific reasoning, representations, and iterative refinement of ideas.

Together, these contextual features frame the implementation of science teaching in Catalan primary education and provide important background for interpreting the findings of the focus group study presented in this report.

3 Method

This study employed a qualitative research design based on focus group discussions. Data were collected through two focus groups conducted in Catalonia with the objective of exploring perceptions, experiences, and needs related to Modeling-Based Learning (MbL) in primary science education (ages 6–12).

3.1 Participants

A total of ten participants took part in the study, organized into two focus groups of five participants each. The composition of the groups was intentional, aiming to capture complementary perspectives from both system-level stakeholders and classroom practitioners with varying degrees of experience in Modeling-Based Learning.

Focus Group 1: Stakeholders in teacher education and system support

The first focus group comprised five stakeholders closely linked to initial teacher education, in-service professional development, curriculum implementation, and institutional support for science education in Catalonia. The participants included:

1. A coordinator responsible for primary science education at CESIRE (*Centre de Suport a la Innovació i la Recerca Educativa*), a pedagogical support centre associated with the Department of Education. This participant coordinates four teacher working groups dedicated to the design of science learning activities in physics, chemistry, biology, and geology.
2. A retired university professor with extensive experience in pre-service and in-service teacher education in science. She currently collaborates with schools on a voluntary basis, accompanying teaching teams in the design and development of science projects.
3. An active university professor who supports and facilitates a teacher innovation group focused on the design, implementation, and collective reflection on the teaching of science in primary education.
4. A professional working in the Department of Education who is involved in the design of the basic competence assessments administered at the end of primary education (grade 6). These large-scale assessments are aimed at monitoring students' attainment of key competences, including those related to scientific reasoning and understanding.
5. A professor affiliated with the Institute of Education Sciences (ICE) at the Autonomous University of Barcelona (UAB), whose role involves providing pedagogical and professional support to school-based teacher groups, particularly in relation to teaching innovation and reflective practice.

This focus group provided a system-level perspective on MbL, addressing issues related to teacher education, curriculum interpretation, assessment practices, and institutional support structures.

Focus Group 2: Primary school teachers

The second focus group consisted of five primary school teachers with differing levels of experience in Modeling-Based Learning:

1. One teacher with no prior experience in MbL.

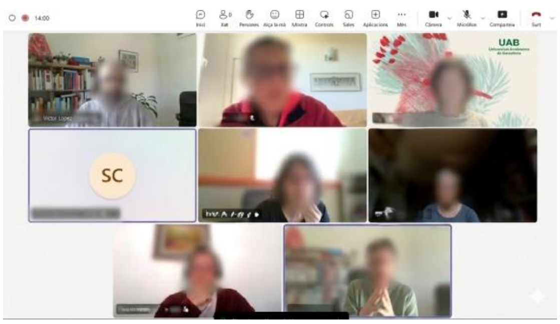
2. Two teachers who were in the early stages of engaging with Modeling-Based Learning and had only recently begun to explore modeling-oriented practices in their science teaching.
3. Two teachers who collaborate regularly with the university, specifically with the Department of Science Education in UAB, and who have some contact with modeling-related ideas and practices. Despite this involvement, these teachers did not consider themselves experts in Modeling-Based Learning.

This group was designed to capture classroom-based perspectives reflecting different stages of familiarity and engagement with MbL within primary education.

3.2 Data collection

Both focus groups were conducted online via the Microsoft Teams platform during the month of April 2026. A semi-structured interview format was used in both sessions, following a common interview protocol developed within the EMPOWER project. The questions addressed participants' understanding of models, modelling, and Modeling-Based Learning; classroom practices in science education; curriculum integration; assessment; and perceived challenges and support needs.

In each focus group, three researchers from the project team were present in addition to the five participants. One researcher acted as moderator, guiding the discussion and posing the interview questions, while the other two researchers independently took detailed notes throughout the session. Participation was voluntary, and ethical considerations were ensured through informed consent, confidentiality, and anonymization of all collected data.



3.3 Data analysis

All focus group sessions were video-recorded. The independently collected notes from the two researchers were subsequently compared and discussed in order to identify convergences, divergences, and complementary perspectives. This process supported the validation and triangulation of interpretations prior to the drafting of the final report.

The transcripts and field notes were analyzed using a thematic analysis approach, focusing on the identification of recurring themes, patterns, and contrasts across and within the two focus groups. Particular attention was paid to differences between stakeholder perspectives and classroom teacher perspectives, as well as to variations associated with participants' levels of experience in Modeling-Based Learning.

4 Findings

4.1 Knowledge

Questions in this section [Q1-Q6] describe how participants talk about and understand models, modelling, and Modelling-based Learning (MbL). What meanings do they attach to these concepts? What role do they see MbL playing in science education? They may also reflect on where their knowledge appears to stem from (e.g. professional experience, teacher education, curriculum documents, policy discussions). Differences or similarities between teachers and stakeholders will be addressed where relevant.

Q1: What do you think are the most important goals for students to learn in science education? Why?

Across both stakeholders and teachers, there is strong agreement that the main goal of science education is to help students understand and interpret the world around them in an active, critical, and meaningful way, rather than simply accepting information as given.

A central idea repeatedly highlighted is the importance of developing a questioning attitude. Participants (both stakeholders and teachers) stress that students should learn to question phenomena instead of just believing explanations. Closely linked to this is the ability to observe carefully, as a stakeholder notes, that although scientific phenomena are all around us, students often do not truly look at or analyze them.

Stakeholders identify further, more concrete goals, such as the need for students to acquire the basic ideas and core models of each scientific discipline. They particularly emphasize that these foundational models help students move from observable facts to reasoned explanations and support a deeper understanding of science as a way of thinking.

Another idea posed by the stakeholders is that students need to understand science as a dynamic process, not merely as static structures or facts, criticizing that now science is presented "like a photograph rather than a film".

Finally, teachers and stakeholders agree that these goals serve broader purposes: enabling students to interpret their immediate environment, understand the context in which they live, and participate actively and critically in society as informed citizens. Science education is thus seen not only as content learning, but as a way to foster critical thinking, autonomy, and engagement with the world.

Q2: What does the term models mean to you in the context of science education?

Across stakeholders and teachers, a *model* in science education is consistently understood as a simplified representation of reality that helps explain, interpret, and connect scientific phenomena in a rigorous way. However, stakeholders give more detailed descriptions of what they think models are, whereas teachers emphasize that the term “models” is not typically used in the teaching environment.

Some descriptions of models that stakeholders give include models as being not mere examples or replicas of reality, but “big ideas”—elegant and abstract constructions that allow many phenomena to be explained through a limited set of core concepts, and that help connect different scientific disciplines. Models are also described by stakeholders as analogous to maps: abstractions that are not reality itself, but selective representations that serve a purpose depending on what one wants to explain. There are multiple models (multiple types of maps) for the same reality, each highlighting different aspects.

Stakeholders also underline that the real challenge lies in making models simple while still functional. Good models reduce the overwhelming complexity of the real world to a manageable “layer of reality” that students can reason with.

Teachers largely agree with the idea of models as representations to explain phenomena, but their responses reveal a significant gap between this theoretical understanding and classroom practice. Many teachers report that although students often end up producing representations, these are not necessarily the result of genuine modeling processes. Modeling is frequently confused with giving examples. Several teachers note that while inquiry-based learning is present in classrooms, explicit modeling and modeling-based learning are rarely made visible or intentional. Furthermore, modeling is described by teachers as an abstract and difficult concept to implement, particularly in primary education and for less experienced teachers.

Q3: What does the term modelling mean to you in the context of science education? // **Q4:** What does the term Modelling-based Learning mean to you in the context of science education?

Both stakeholders and teachers share the view that modelling is inherently procedural, combining conceptual learning with skills such as questioning, reasoning, and revising explanations. One stakeholder notes that this requires teachers to anticipate students’ initial ideas and to have a clear final goal where the students need to arrive.

A central emphasis is placed on the strong link between models and real phenomena. Stakeholders warn that models disconnected from experience or observation lose meaning, stressing the importance of experimentation and real-world contexts. Modelling is therefore understood as a way to reason about intangible elements of science (e.g. particles, forces) that cannot be directly observed.

Teachers highlight again a gap between theory and classroom practice. Modelling is often reduced to building maquettes or representations, without engaging students in an actual modelling cycle. Teachers report that although initial ideas regarding a model may be elicited, they are rarely revisited, as instruction often returns to teacher explanations rather than student reasoning. The "what" is often more developed and worked with than the "how" or the "why".

Implementing MbL is perceived as challenging because it requires moving away from traditional, teacher-centered pedagogy, greater coordination among teachers, and sustained professional development. One teacher reported having suggested to introduce the topic of nutrition in a holistic way but the idea was perceived as strange by other teachers, who insisted on teaching it divided by systems (the gastrointestinal system, etc.).

Q5: Where does this knowledge you have about models, modelling and MbL come from?

Stakeholders indicate that their understanding of models, modelling, and MbL comes primarily from professional experience and sustained training, rather than from their own initial education. They point out that most educators did not learn science through modelling themselves, which makes both understanding and implementation more difficult. According to the interviews, successful experiences with modelling-based approaches are closely linked to extensive teacher training.

Q6: What is the role of models, modelling and MbL in Science Education?

Even though this question was not explicitly posed to participants, stakeholders reported the importance of models as a rigorous approach to scientific learning and to the understanding of phenomena. Some stakeholders also emphasized that science is not "like this just because it is", and models show that since they evolve through time.

4.2 Teaching experience

Questions in this section [Q7-Q11] describe how MbL is experienced in practice. How do teachers report using models and modelling in their teaching? What roles do they see for themselves and for students? What learning goals are associated with MbL, and how are these approached or assessed?

Q7: Do you explicitly address models in your teaching? If yes, how (example!)? If not, why not? [(why) do you think it (explicitly addressing models) is useful for your students?]

Teachers report that models and modelling are rarely addressed explicitly in primary science classrooms. Most participants indicate that they have encountered very few examples of teaching practices that intentionally focus on Modeling-Based Learning. When modelling-related activities do occur, they are usually embedded indirectly within broader or cross-curricular projects, such as kitchen chemistry activities or explorations of the school environment, rather than being treated as a distinct instructional focus. As a result, models tend not to be discussed as conceptual tools, and the term "model" itself is often absent from classroom discourse. Teachers do not generally perceive explicit attention to modelling as a common or expected practice in primary science education.

Q8: What is your role as a teacher in supporting students' understanding of models and modelling? And what is your role in supporting their learning of science using models and modelling?

Teachers describe their role in supporting students' understanding of models and modelling as strongly shaped by their own confidence and perceived expertise in science. Many participants report feeling insecure when teaching science and therefore tend to limit their instructional choices to content and activities they feel comfortable with. This insecurity is not linked to a lack of interest in science, but rather to uncertainty about how to teach scientific concepts and how to engage students in modelling processes. As a consequence, teachers often position themselves as facilitators of predefined activities rather than as guides who support students in constructing, testing, and refining models. Participants emphasize the need for clearer guidance, exemplars, or expert reference points to help them assume a more active role in modelling-based teaching.

Q9: Do you actively involve your students with modelling practices such as creating, using, or revising models? If so, with which ones and how? If not, why?

Teachers report that students are rarely involved systematically in modelling practices such as creating, using, or revising models. Classroom work typically relies on textbooks or externally designed sequences, reflecting a strong tradition of content delivery rather than model construction. Although students frequently produce representations, these products are not usually the outcome of explicit modelling processes. This situation is illustrated by the common example of the water cycle, where learning is often reduced to reproducing the canonical diagram with arrows, without engaging students in reasoning about why the phenomenon is represented in that way, what assumptions the model makes, or how it could be modified. Overall, modelling is often conflated with illustrating content, rather than being approached as a dynamic process of explanation and revision.

Q10: What are the main challenges you and your students face in using/applying models and modelling in your classes?

Participants identify multiple interconnected challenges that hinder the use of models and modelling in primary classrooms. A central issue is the low priority often given to science compared to other subjects, both in daily school practices and in internal professional development, which results in irregular and fragile science teaching. This situation is closely associated with teachers' lack of confidence and with insufficient and poorly structured training. Many teachers describe their preparation in science as largely autodidactic and consider initial teacher education to be insufficient, particularly when compared to secondary education. The generalist profile of primary teachers is perceived as an additional barrier, reinforcing dependence on textbooks and predefined materials. Furthermore, teachers highlight that curricular guidelines are often perceived as unclear, leaving them uncertain about expectations in science education and discouraging experimentation with modelling-based approaches.

Q11: What are your target learning outcomes when using MbL? And how do you evaluate them?

Teachers' responses suggest that learning outcomes related to Modeling-Based Learning are rarely defined explicitly. In most cases, assessment practices focus on final products, such as drawings or worksheets, rather than on students' reasoning processes, use of representations, or ability to revise and improve models. As a result, evaluation tends to privilege the correctness or completeness of representations over deeper engagement with modelling as a scientific practice. This contributes to a limited visibility of modelling-related learning goals and reinforces a focus on tangible outputs rather than on explanatory coherence or conceptual development.

4.3 Curriculum integration

Questions in this section [Q12-Q13] describe how teachers perceive the role of the national curriculum in relation to models, modelling, and MbL. How do teachers experience curriculum expectations in their daily practice? Do they feel supported, constrained, or guided by current curriculum frameworks? From the stakeholder perspective, how is MbL positioned within the broader educational system? What intentions, priorities, or challenges are associated with curriculum-level decisions?

Q12: How does the national curriculum influence the use of models and modelling in your teaching practices?

On the one hand, the curriculum is seen by teachers as facilitating modelling in principle, because it is open and flexible. It indicates the learning goals teachers are expected to reach,

which can allow schools to organize teaching according to their own approaches. However, this same openness is also described as problematic: several teachers note that the curriculum is too broad, making planning difficult and leaving teachers feeling lost when they have to decide how to structure science learning.
Another difficulty concerns progression and assessment criteria. When the same evaluation criteria apply across different educational stages, teachers feel the responsibility of defining levels and progressions themselves, which adds to their uncertainty. In addition, although the term *model* appears frequently in the curriculum, it is often used in an exemplary or illustrative sense, rather than as a scientific model. The concept of *modelling* as a learning process is largely absent.
As a result, teachers report that the curriculum does not provide a clear reference or entry point for modelling-based learning. Without explicit mention or guidance on modelling, it is difficult for teachers to develop an initial understanding of how to integrate it into their practice.

Q13: What are the main tools, manuals, and teaching materials available in your country that help you in applying MbL?

Teachers mention very few concrete tools or materials that explicitly support the application of Modelling-based Learning. One of the main resources highlighted is *"El Tresor de Recursos"* (see references), which is a website with material that helps teachers understand scientific models and how to work with modelling processes in the classroom. However, its use is not widespread.

One teacher emphasizes that applying MbL requires not only access to materials, but also professional curiosity and personal initiative to search for resources, rethink instruction, and support students in reasoning rather than reproducing information.

4.4 Teacher support and needs

In this section, questions [Q14-Q15] focus on describing the kinds of support participants consider important for strengthening MbL. This may include professional development, teaching materials, structural conditions, collaboration opportunities, or system-level changes.

Q14: What would help you in (further) using models and modelling in your classes? // **Q15:** Do you think there is a need for teachers to receive more support in using models and modelling in science classrooms? Please explain why or why not.

Both stakeholders and teachers strongly agree that more and better support is needed for teachers to effectively use models and modelling in science classrooms. The main needs identified relate to conceptual understanding, professional habits, training, and collective school practices.

When asking the stakeholders, they report that we should move away from a focus on whether students *"know or don't know"* toward the students asking themselves "how can I explain it?". Stakeholders also criticize the dominance of vocabulary-based teaching, describing it as a major obstacle to modelling. In addition, they claim that teachers are not used to this type of learning and teaching, since it is not a common practice in most schools, so they do not think that this is the way to teach science. Furthermore, modelling itself is described by stakeholders as highly abstract, counterintuitive, and demanding, which makes it hard for teachers and students alike.

On the other hand, teachers emphasize that lack of confidence and insufficient content knowledge in science are central barriers. Many do not feel competent to teach science or guide students' thinking, which leads them to rely heavily on textbooks. This dependence is reinforced by the fact that a large proportion of primary teachers have not studied science beyond compulsory secondary education, and by the lack of clear guidance or ready-to-use materials from educational authorities. When teachers leave the textbook behind, they feel they need a very concrete alternative, which conflicts with the open and student-centered nature of modelling.

When asked about what would help, teachers' suggested measures include:

- A shared pedagogical debate within schools about how science is taught to be able to decide about formative processes that can in turn become education projects.
- Need for a collective process, to create and share clear progressions of ideas and teaching materials and resources across grade levels.
- Maps of learning progressions that take students' prior ideas into account.
- Concrete resource banks and documented classroom practices.
- Opportunities to observe good practices, such as pedagogical visits to other schools.
- In-school support, such as subject leaders or experts to consult when difficulties arise.
- Access to examples of classroom dialogues, helping teachers imagine how modelling-based activities unfold in practice.

5 Conclusions

The interviews present MbL as a highly valued but weakly consolidated approach in current science education practice in Catalonia. Across stakeholders and teachers, there is a consensus that models and MbL are useful for meaningful science learning, yet their implementation remains fragmented, difficult, and limited to a minority of contexts.

Even though MbL is described and defined clearly by stakeholders and identified as a rigorous framework for scientific understanding, teachers show a vaguer idea of what MbL is and how it can be beneficial for their teaching practice. Some reasons why stakeholders value MbL include: (i) that it helps students make sense of phenomena, especially those involving abstract or intangible entities, (ii) that it relies on core ideas or "big models" that allow many phenomena to be explained with relatively simple representations, and that (iii) it encourages active thinking, questioning, and explanation, rather than memorization or knowledge reproduction.

Despite a general positive attitude towards MbL, the interviews reveal significant and persistent barriers to using MbL in everyday practice. A central challenge is teachers' lack of confidence and preparation in science. Primary school teachers report limited scientific background, minimal exposure to modelling during their own education, and a strong sense of insecurity when teaching science. This insecurity leads to excessive reliance on textbooks and prescriptive content sequences and a focus on vocabulary and content, rather than explanation and reasoning. Modelling itself is described as abstract, counterintuitive, and demanding.

Regarding the connection of MbL to national curriculum, teachers perceive the curriculum to be too open and unspecific, offering goals without clear guidance on how to achieve them.

In order to enhance the use of MbL in the teaching practice, teachers highlight the need for support, including concrete examples of practice, such as documented classroom cases, examples of teacher–student dialogue, and opportunities to observe other schools that use MbL as usual teaching practice.

Overall, the interviews portray MbL as a shared aspiration that is not yet structurally supported. Its potential is widely recognized, but realizing it requires changes in teacher preparation, school culture, curriculum interpretation, and long-term professional learning.

6 References

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