EMPOWER

CONSOLIDATED REPORT

TEACHERS' NEEDS AND CURRENT TEACHING PRACTICES FOR MODELLING-BASED LEARNING IN FOUR COUNTRIES

2026

EMPOWER

Empowering Teachers for Science Learning Through Modelling-Based Approaches

IPN | European University Cyprus | SOSCIEATH | University of Cyprus | Radboud Universiteit | Utrecht University | UAB Universitat Autònoma de Barcelona | Co-funded by the European Union | Erasmus+ Enriching lives, opening minds.

Erasmus+ Project EMPOWER

EMPOWERING TEACHERS FOR SCIENCE LEARNING THROUGH MODELLING-BASED APPROACHES

Project-Team of the Workpackage (alphabetical order)

Tom Bielik (SRU), Evridiki Eracleous (EUC), Carme Grimalt-Álvaro (UAB), Felicitas Haupts (IPN), Wouter van Joolingen (UU), Moritz Krell (IPN), Kim Krijtenburg-Lewerissa (UU), Kim Eleni Lobner (IPN), Andrea López-Incera (UAB), Víctor López-Simó (UAB), Loucas Louca (EUC), Anna Marbà-Tallada (UAB), Marios Papaevripidou (UCY), Chloi Savvidou (EUC), Ronja Sowinski (IPN), Kyriaki Vakkou (UCY), Esther Zeedijk (SRU)

Contents

1 Introduction

This report presents the outcomes of a qualitative study conducted within the EMPOWER project, which aims to build a clearer understanding of current practices, challenges, and needs related to Modelling-based Learning (MbL) in science education. Through a series of focus group interviews with in-service teachers and educational stakeholders in Germany, Cyprus, Spain, and the Netherlands, the study explores how models and modelling are understood, how they are used in teaching and learning, and what forms of support are needed to strengthen their role in science education. The focus groups were designed to capture both classroom-level experiences and broader institutional or curricular perspectives, providing a broad perspective on the conditions that shape MbL implementation.

The findings reported here serve two purposes. First, they offer country-specific insights into teachers' and stakeholders' experiences with models, modelling, and MbL, highlighting contextual factors that influence practice. Second, they contribute to a cross-country synthesis that identifies shared challenges, emerging opportunities, and areas where further support or development is needed. Together, these insights provide a foundation for designing targeted professional development, developing supportive materials, and informing future curriculum development efforts aimed at strengthening modelling-based science education across Europe.

2 Method

This study employed semi-structured focus group interviews to investigate teachers' and stakeholders' perspectives on MbL in science education across participating countries. The aim was to document current practices, challenges, and needs, and to produce both country-specific reports and a cross-country synthesis. Participants included in-service science teachers and national stakeholders such as curriculum developers, policymakers, and teacher educators. Recruitment was organised locally in each country (see Table 1).

Table 1 *Participants in the focus group interviews*

Country	*Focus group nr.*	*Participating teachers*	*Participating stakeholders*
Germany	1	4 secondary school teachers with diverse subject backgrounds and varying levels of experience with MbL	3 stakeholders involved in teacher education, professional development, curriculum implementation, and institutional support for science education
Cyprus	1 (UCY)	5 primary school teachers familiar with a range of instructional practices, including MbL	4 stakeholders holding institutional roles in science education, including inspectors and consultants involved in

			curriculum implementation and teacher support
	2/3 (EUC)	10 kindergarten teachers (two focus groups of five), with varying levels of experience in MbL	-
Spain	1	5 primary school teachers with varying levels of experience in MbL	5 stakeholders connected to primary and secondary teacher education, curriculum implementation, assessment development, and pedagogical support structures in science education
The Netherlands	1 (SRU/UU)	4 secondary school teachers in physics, biology and chemistry with experience in MbL	3 stakeholders covering publishers, teacher education, educational research for secondary education
	2 (SRU/UU)	3 secondary school teachers in physics and biology with experience in MbL	4 stakeholders covering curriculum developers, test developers, teacher educators and educational researchers for secondary education.

Each focus group lasted approximately 60-90 minutes and followed a shared interview protocol. The protocol ensured consistency across countries while allowing moderators to adapt the flow of the discussion when relevant topics emerged organically. Each session began with a short introduction in which the moderator explained the purpose of the study, referred to the information letter, and reminded participants of their rights, including voluntary participation, anonymisation, and secure data handling. Consent was confirmed through continued participation. The protocol consisted of two parallel versions – one for teachers and one for stakeholders – each organised into thematic sections.

The teacher protocol focused on:

1. teachers' knowledge and views on models, modelling, and MbL;
2. their teaching experiences and modelling practices;
3. connections to the national curriculum; and
4. perceived needs for further support.

The stakeholder protocol addressed:

1. stakeholders' knowledge and views on models, modelling, and MbL;
2. the status of MbL in the national curriculum;

3. available resources and system-level support; and
4. needs for strengthening modelling-based science education.

Moderators used the questions as prompts to stimulate discussion, encouraged elaboration when needed, and ensured balanced participation. Questions could be skipped if the topic had already been addressed, and all interviews ended with a question about what teachers need in order to further integrate modelling in their classes. Each session concluded with a brief closing and the termination of the recording. After the session, the interviews were transcribed and anonymised.

3 Findings

Across the participating contexts, the interviews reveal a broadly shared recognition of the educational value of models, modelling, and MbL, alongside notable variation in how these concepts are understood, enacted, and supported. While the structural and curricular conditions differ, the findings collectively highlight the central role that models play in helping students make sense of complex or invisible scientific phenomena, as well as the challenges teachers face in implementing modelling as an iterative scientific practice. The synthesis below compares perspectives across Germany, Spain, Cyprus, and the Netherlands, focusing on four thematic areas.

3.1 Knowledge

Across all contexts, participants describe models as representations of reality that help explain and predict scientific phenomena, but their knowledge and interpretations differ across groups and countries. Stakeholders generally express more epistemic and process-oriented understandings, while teachers more often frame models in terms of their explanatory or illustrative classroom functions. In **Germany**, stakeholders and secondary school teachers say their knowledge of models and modelling comes from teacher education, preparatory service, and classroom experience. Teachers emphasise models as purposeful explanatory tools and tend to regard modelling as constructing models, whereas stakeholders describe modelling as a broader scientific practice involving testing, revising, and critiquing models. In **Cyprus**, the teachers' knowledge stems largely from postgraduate studies. More experienced kindergarten teachers view modelling as children building and improving their ideas, while less experienced teachers view it mainly as hands-on exploration. Primary teachers describe modelling as making children's thinking visible and helping them adjust it, and stakeholders see it as a broader scientific skill that supports inquiry and critical thinking. In **Spain**, stakeholders say their knowledge comes mainly from professional experience and sustained training, while primary school teachers report that they did not learn modelling in their own education. Both groups understand modelling as a step-by-step process that involves questioning, reasoning, and revising explanations. However, teachers say their

knowledge of how to carry out this full cycle is mostly theoretical and difficult to apply in practice. In **the Netherlands**, secondary school teachers and stakeholders say their knowledge comes mainly from personal interest and professional development, with several noting that modelling was not part of their teacher education. Teachers and stakeholders describe modelling as an iterative process of constantly testing and changing models and some highlighted modelling as a social practice, involving collaboration and discourse within scientific communities.

3.2 Teaching experience

Across the different countries, teachers' modelling experiences are shaped by curricular expectations, confidence in science teaching, and the extent to which modelling is embedded in everyday practice. While teachers often value modelling, their classroom enactments vary widely and are frequently constrained by time, materials, and established routines. In **Germany**, secondary school teachers report that they explicitly address models, often highlighting their limitations. Students regularly create and use models, though systematic revision is less common. Teachers describe their role as structuring and facilitating modelling activities – selecting models, defining tasks, and scaffolding complexity – while allowing space for independent engagement. Challenges include choosing suitable models, defining criteria, and balancing ambition with classroom realities. In **Cyprus**, kindergarten teachers use modelling as an activity in which children actively create and discuss representations, but the depth of engagement varies with teacher experience. More experienced teachers guide children through all phases of modelling, whereas less experienced teachers focus mainly on the construction of models. Primary school teachers report that they use models and elements of modelling across a variety of topics, such as electricity, the circulatory system, the solar system, the digestive system, and the human body. Across both levels, teachers face difficulties related to age appropriateness, limited time, and limited materials. In **Spain**, primary school teachers rarely address models explicitly, and modelling seldom appears as a distinct instructional focus. Activities involving models typically occur indirectly within broader projects, and the term 'model' itself is often absent from classroom discourse. Teachers often feel insecure about teaching science and rely heavily on predefined materials, positioning themselves as facilitators rather than guides in constructing or revising models. Limited confidence, unclear curricular expectations, and low priority for science contribute to fragile modelling practices. In **the Netherlands**, secondary school teachers report diverse modelling experiences, including the use of concept mapping, computational modelling, and the use of didactical models. Teachers also use discipline-specific general models, such as the particle model, within their lessons, embedding modelling within subject-specific lessons.

3.3 Curriculum integration

Curricular frameworks in all contexts acknowledge scientific reasoning, but the explicit positioning of modelling varies and often lacks operational clarity. In **Germany**, modelling is

embedded in national standards, yet teachers rely more on school-internal curricula that emphasise content. In **Cyprus,** modelling is referenced but not sufficiently specified, leading teachers to depend on professional development and personal initiative. In **Spain**, the competence-based curriculum is open but vague, leaving teachers uncertain about how modelling fits. In **the Netherlands**, modelling appears in examination programmes, especially in physics and chemistry, but the curriculum emphasises *using* models rather than *modelling as a process*. Teachers report that exam expectations reinforce the application of established models rather than iterative model development.

3.4 Teacher support and needs

Across countries, teachers express a strong need for more structured, practical, and sustained support to use modelling-based learning effectively in science classrooms. In **Germany**, stakeholders highlight the need for systematic professional development that builds conceptual clarity about what models are and how to use them purposefully. They frequently observe classroom difficulties when models are used without explicit attention to their representational nature. Teachers call for centrally provided, high-quality materials aligned with curriculum requirements and express dissatisfaction with having to develop resources on their own, indicating support is needed at both classroom and system levels. In **Cyprus**, kindergarten and primary school teachers emphasize the need for targeted professional development that clarifies what modelling is and how it can be applied across grades. They also request repositories of tried-and-tested materials – lesson plans, prompts, simulations, and practical examples – because developing such resources independently is time-consuming. Teachers highlight material and structural constraints, including limited space, lack of laboratories, insufficient equipment, and time pressure that restricts opportunities for inquiry, discussion, and model revision. Stakeholders similarly stress that teachers would benefit from more concrete examples of implementation. Kindergarten teachers additionally emphasize the need for practical, school-based guidance, clear lesson structures, and reliable materials, pointing out that modelling currently depends heavily on personal initiative rather than systematic support. In **Spain**, teachers and stakeholders agree that substantial support is required. Teachers report limited confidence and insufficient science content knowledge, leading to heavy reliance on textbooks. They request clear learning progressions, concrete resource banks, examples of classroom dialogue, and opportunities to observe good practice. Stakeholders emphasize the need to shift away from vocabulary-based teaching and note that modelling is often perceived as abstract and counter-intuitive, making professional development essential. In **the Netherlands**, teachers and stakeholders identify needs for solid teaching tools, exemplar exam questions, and clearer integration of MbL into textbooks and assignments. They value active learning communities and call for continuous learning progressions across secondary education so that modelling returns consistently rather than sporadically. Teacher training – especially for computational modelling – is seen as essential for building technical affinity and scientific

literacy. Stakeholders also highlight the importance of raising awareness among teachers and students about the role of modelling in STEM subjects.

4 Conclusions

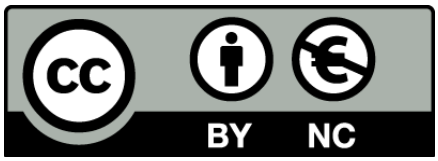
Across Germany, Spain, Cyprus, and the Netherlands, the study reveals a shared recognition of the educational value of **models**, **modelling**, and **MbL**, but also substantial variation in how these practices are understood, enacted, and supported. Teachers and stakeholders consistently describe models as essential tools for explaining complex or invisible phenomena, yet their interpretations of modelling differ: teachers often emphasize constructing or using models, while stakeholders frame modelling as an iterative scientific practice involving testing, revising, and critiquing models.

Classroom practices vary widely. In Germany, teachers regularly use and discuss models, though systematic revision is less common. In Cyprus, both primary and kindergarten teachers use models across many topics, but depth of engagement depends strongly on teacher experience and available resources. In Spain, modelling is rarely explicit, often embedded indirectly in broader projects, and constrained by limited teacher confidence and reliance on textbooks. In the Netherlands, modelling appears in diverse forms, but is shaped heavily by time constraints and exam expectations.

Curriculum integration is uneven. Germany embeds modelling in national standards, but the teachers interviewed rely more on school-internal curricula. In Cyprus, modelling has an important place in the curriculum, yet guidance remains insufficiently specific, leading teachers to depend on professional development and personal initiative. Spain's curriculum is flexible but open, leaving teachers uncertain about how to implement modelling. In the Netherlands, modelling appears in the curriculum, but teachers report that the lack of urgency – partly because modelling is not strongly emphasized in examinations – means that many do not integrate it into their teaching.

Across all countries, teachers express a strong need for structured, practical, and sustained support. They request clearer conceptual foundations, high-quality materials, time, and collaborative structures. Professional development is universally emphasized, especially training that combines theoretical understanding with practical classroom examples. Teachers also highlight systemic constraints – limited time, insufficient materials, and unclear curricular expectations – that hinder modelling as an iterative scientific practice. These shared needs point to the importance of coordinated efforts in professional development, curriculum design, and resource development to strengthen modelling-based science education across Europe.

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the National Agency. Neither the European Union nor the granting authority can be held responsible for them.



EMPOWER

Empowering Teachers for Science Learning Through Modelling-Based Approaches