EMPOWER NATIONAL REPORT ON THE USE OF MODELING-BASED LEARNING IN CURRICULA – CATALONIA (SPAIN)

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EMPOWER

Empowering Teachers for Science Learning Through Modelling-Based Approaches

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EMPOWERING TEACHERS FOR SCIENCE LEARNING THROUGH MODELLING-BASED APPROACHES

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1 Introduction

This report examines how modelling-based learning (MbL) is represented in the Catalan primary education curriculum, as part of the EMPOWER project. The Catalan curriculum (Departament d'Educació, 2022) constitutes one of the regional implementations of the general curricular guidelines established at the national level in Spain (Ministerio de Educación y Formación Profesional, 2022), because of its decentralized educational system. The report analyses references to models and modelling in the curriculum in order to identify how modelling is represented and the role it plays within science education.

2 Methodology

This report is based on a qualitative content analysis of the official "environment" curricula for primary education, specifically Grades 1 to 6 (student ages from 5 to 12).

As a first step in the analysis, all occurrences of the term model in the Catalan primary curriculum for Medi natural, social i cultural were identified. This curriculum is presented in a 25 pages document that can be found in Departament d'Educació (2022): https://xtec.gencat.cat/web/.content/curriculum/primaria/curriculum-175-2022/Coneixement-del-Medi-Natural-Social-i-Cultural.pdf

However, not all occurrences correspond to modelling in the sense of scientific modelling or modelling-based learning (MbL), as defined within the EMPOWER framework. The term model is used in the curriculum with multiple meanings, many of which are unrelated to the construction, use, evaluation, or revision of scientific representations (see Table 1).

To ensure consistency with the analytical framework adopted in this project, each occurrence was carefully examined in context and classified according to its meaning. Only those references that correspond to modelling as a scientific practice—particularly in relation to inquiry processes and representation of phenomena—were considered relevant for the analysis of modelling-based learning. Other occurrences were excluded from the analysis, as shown in the following table.

Meaning	Where does it appear?	Example of statement in curriculum
Model within an IBSE framework.	Scientific Culture: Initiation to scientific activity	*Selection of inquiry techniques (observations, identification and classification, formulation of questions and predictions, planning and carrying out experiments and investigations, pattern seeking, model creation, information and data searching, experiments with control of variables, communication*

		of results…) appropriate to the needs of the investigation."
Model referring to artifact resulting from a design process	Competence 3 (Problem solving)	*To contribute ideas that can provide an answer to a problem or need, according to different forms of reasoning, such as design thinking or computational thinking, sharing them through oral descriptions, representations, and models, and to cooperatively establish criteria to evaluate the project and the management of joint work."*
Model as socio-economic framework or normative way of organising society,	Competence 5 (Heritage) and Competence 6 (Eco-social issues)	*"Conservation and improvement of natural and cultural heritage, considering it as a common good, since respect for nature begins with the adoption of a different model of economic development."*
Model referring to exemplary behaviours	Competence 8 – Gender and equality	*"To demonstrate attitudes that promote equity, gender equality and non-sexist behaviours by recognising positive models in the immediate environment."*

Table 1. Different usages of word "Model" in curriculum

The analysis focused on identifying all references to models and modelling based on the first of the definitions in Table 1. To ensure consistency, a common coding scheme, developed and agreed upon within the consortium, was used to categorize the identified instances. In addition to the predefined codes, supplemental codes were introduced under the category "other" to capture cases that were not fully captured by the initial framework. A summary of the coding scheme and the identified instances is presented in Table 2 below.

Category	Sub-Category
Definitions of modelling competence	Specified
	Not specified
Significance of models	Significance of models in the natural sciences
	Significance of models in the educational process
	Significance of models in the modelling process in Science
	Not specified
Types of models	Mental
	Conceptual map
	Physical
	Models available in the school biology lab
	Simple model
	3D model
	Diagrams
	Drawing
	Other

	Not specified
Contexts of model use	
Modelling practices	Model creation
	Model use/selection of models
	Model evaluation
	Model revision
	Not specified
Meta-modelling knowledge	Knowledge about the properties and functions of models
	Knowledge of the modelling process
	Not specified
Other	Significance of Modelling-Based Reasoning
	Use of models to understand the concept of a Physical System
	Other
	Not specified
Aim of text	For the teacher
	For the student
Ways/strategies of using MbL	Ready-made models
	Ready-made models by other students
	Develop models from scratch
	Not specified

Table 2. Coding scheme used for the analysis of modelling references

The coding scheme was designed to capture the multidimensional representation of modelling within the curricular texts through a comprehensive set of interrelated categories and subcategories. Initially, the framework identifies (1) the definitions of modelling competence, distinguishing between specified and not specified instances. The second component of the scheme involves (2) the significance of models, which categorizes whether the text mentions the importance of models in the natural sciences, the educational process, or the modelling process in science, thereby capturing their conceptual role within the curriculum. Furthermore, (3) the scheme identifies various types of models, such as mental, conceptual maps, physical, 3D models, diagrams, drawings, and models available in the school biology labs, while a fourth component records (4) the contextual area that models are used across biological thematic areas such as the introduction of the text, living organisms, cells, human reproduction, nutrition, digestive system, circulatory system, ecological pyramids, and human physiology. MbL practices are also examined by (5) coding the actions required from students during teaching and learning with models – specifically model creation, use/selection, evaluation, and revision – whereas (6) meta-modelling knowledge codes distinguish between knowledge about the properties and functions of models and knowledge of the modelling process itself. Supplemental categories were introduced under "other" (7) to capture instances such as the discussion of the significance of modelling-based reasoning or the use of models to understand physical systems. Finally, the framework records (8) the aim of the text (directed at the teacher or the student) and (9) the specific ways or strategies of using MbL, such as the use of ready-made models or developing models from scratch, while consistently coding cases lacking explicit information as “not specified” to maintain analytical transparency.

3 Background

The Spanish education system is organised into several stages that together constitute what is known as “basic education”, a compulsory period that spans from ages 6 to 16. Within this structure, “primary education” covers the first six years (ages 6–12), followed by “compulsory secondary education” (ages 12–16). The present report focuses exclusively on the primary education stage, as this corresponds to the age range targeted in the implementation of EMPOWER project in Spain.

In primary education, the curriculum is organised into eight subject areas, being “Natural, social and cultural environment” one of them. This subject integrates three disciplinary domains: experimental sciences, social sciences, and technology/engineering, and it is usually associated to 3h / week in schools. This integrated subject provides a broad and interdisciplinary framework that introduces pupils to the natural and social world while progressively fostering scientific inquiry, digital competencies, and technological literacy. For the purposes of the EMPOWER analysis, our focus is placed specifically on the components related to experimental sciences.

Although education in Spain is regulated through a “basic national curriculum”, the autonomous communities develop their own curricula within this overarching framework. In the case of Catalonia, the curriculum for primary education is aligned with the structure, aims and competences established at the national level, while introducing some adjustments that primarily affect the social sciences component (notably geography and history). Importantly, there are no substantial differences between the Catalan and national regulations regarding the natural sciences.

The structure of the curriculum is articulated around two complementary elements: (a) “competences” and (b) “basic knowledge”. Competence defines what learners are expected to be able to do by the end of the stage, whereas “basic knowledge” represents the conceptual and procedural knowledge that contributes to the development of those competences.

The ten competences in the primary curriculum include (1) the use of digital resources, (2) scientific thinking, (3) problem solving, (4) understanding of human biology, (5) natural and social systems, (6) human action, (7) natural and social changes, (8) diversity and equality, (9) social participation, and (10) values and coexistence. Of these, competences 2, 3 and 4 are particularly relevant for the analysis of Modelling-based Learning (MbL).

Parallel to the competences, the "basic knowledge" is structured into three main blocks that correspond to the disciplinary domains mentioned earlier (a) Scientific culture; (b) Technology and design, (c) Society and territory. Within "Scientific culture" block, which is the main area of interest for this report, the content is further organized into four subdomains: (a) Introduction to scientific activity (procedural and epistemic knowledge, including observation, experimentation, model construction and scientific communication); (b) Life in the Earth (that is, Biology), (c) Matter, forces and energy (that is, Physics and chemistry); (d) Challenges of the world (that include geology and climate science).

Finally, it is also important to note that the term "modelling" appears elsewhere in the curriculum, notably in the mathematics subject, where it is associated with mathematical modelling for problem solving. However, this mathematical use of the term differs both in purpose and epistemic foundations from the notion of scientific modelling that underpins MbL, and should therefore be considered separately in the analysis.

4 Findings

The analysis of the Catalan curriculum identified a total of 14 occurrences of the term model, which were found to represent different meanings depending on the context in which they appear. The following table summarises these meanings and their frequency of occurrence across the curriculum.

Meaning	Number of times it appears
Model within an IBSE framework.	2
Model referring to artifact resulting from a design process	3
Model as socio-economic framework or normative way of organising society,	5
Model referring to exemplary behaviours	6

Table 3. Number of times that "model" appears in the curriculum according to its different meanings.

4.1 Strategies for using MbL

No explicit strategies for the use of modelling-based learning were identified in the Catalan primary curriculum. The analysed references do not specify whether students are expected to work with ready-made models, models developed by others, or models constructed from scratch. As a result, all instances were coded as not specified. This suggests that the curriculum does not provide explicit guidance on how modelling activities should be implemented in classroom practice.

4.2 Definitions of modelling competence

No references to definitions of modelling competence were identified in the analysed curriculum. None of the 2 instances explicitly describe modelling as a competence or outline the knowledge and skills associated with modelling. Therefore, these were coded as *not specified*. This indicates that modelling is not explicitly conceptualised as a distinct competence within the curriculum.

4.3 Significance of models in the natural sciences

No references were identified that explicitly address the significance of models in the natural sciences, in the educational process, or within the modelling process itself. All instances were therefore coded as *not specified*. This suggests that the curriculum does not explicitly articulate the role of models as epistemic tools for understanding, explaining, or predicting scientific phenomena.

However, this absence can be further interpreted in relation to how scientific activity is framed in the curriculum. The emphasis tends to be placed on "discovering the world" through observation and experimentation, rather than on "interpreting the world" using conceptual tools. While discovery prioritises direct engagement with observable phenomena, interpretation requires representations—such as models—that allow students to account for unobservable mechanisms, formulate explanations, and establish causal relationships. In this sense, the curriculum aligns more closely with a procedural view of science than with a modelling-based perspective. Although the notion of *model* is not explicitly developed, related terms such as "vision" (e.g., a vision of how systems work) appear occasionally and may function as implicit forms of modelling. Nevertheless, this potential remains unarticulated, limiting the visibility and epistemic role of modelling in the curriculum.

4.4 Types of models

No specific types of models were identified in the analysed references. None of the instances explicitly refer to physical, conceptual, digital, diagrammatic, or other types of models. Consequently, the two references were coded as *not specified*. This indicates that the curriculum does not provide explicit indications regarding the nature or diversity of models that students are expected to engage with.

However, the curriculum does include explicit references to core scientific ideas that correspond to well-established school models, particularly within different content areas. For example, in the biology block, the study of matter cycles and energy flow in ecosystems, including relationships between producers, consumers, and decomposers, is presented as a key learning goal. These descriptions align with widely recognised ecological models used in science education. Nevertheless, these ideas are not explicitly framed as models, nor is their representational nature made visible. As a result, while the curriculum implicitly builds on canonical scientific models, it does not explicitly identify or treat them as such.

4.5 Contexts of model use

Considering the vague, implicit, and tangential presence of model-based and modelling-based approaches throughout the curriculum discussed above, we assume that the contexts in which MbL can be meaningfully implemented correspond to the major scientific ideas or canonical school science models. According to the curriculum, these are:

- Human body
- Ecosystems
- Living beings
- Floating
- Changes of matter
- Electricity production and consumption
- Energy sources
- Forces and simple machines
- Light and sound
- Aerodynamics
- Water cycle and properties
- Atmosphere, geosphere and earth as a system
- Climate change

4.6 Modelling practices

All identified references to modelling correspond to *model creation*, which accounts for 100% of the coded instances. No references were found for other modelling practices such as model use, model evaluation, or model revision. This indicates that modelling in the curriculum is limited to the construction of models, without explicit attention to their use, assessment, or refinement as part of an iterative process.

However, some elements of modelling practices can be indirectly identified in the way scientific competences are operationalised through evaluation criteria. For instance, in early primary levels (Years 1–2), students are expected to compare results with initial predictions in order to formulate possible answers to investigable questions, while in later stages (Years 5–6), they are required to analyse and interpret data and predictions to assess the coherence of proposed explanations. These processes can be associated with the use and revision of models, as predictions are typically grounded in implicit representations of how systems behave. In this sense, prediction can be interpreted as an instance of *model use*, while the comparison between predictions and results introduces elements of *model evaluation* and *revision*. Nevertheless, these connections remain implicit, as the curriculum does not explicitly frame such practices in terms of modelling.

4.7 Meta-modelling knowledge

No references were identified that address meta-modelling knowledge, either in terms of understanding the properties and functions of models or knowledge of the modelling process. All 2 instances were coded as *not specified*. This suggests that the curriculum does not explicitly promote reflection on the nature, purpose, or limitations of models.

4.8 Aim of the text

All identified references are addressed to students, as they appear within descriptions of learning activities or expected practices. No references were identified as being specifically addressed to teachers. This indicates that modelling is presented as a student activity rather than as part of pedagogical guidance.

5. Conclusions

The analysis of the Catalan primary curriculum reveals a very limited explicit presence of modelling within the curriculum text. Only two references to modelling were identified, both associated with model creation within the context of scientific inquiry, while all other dimensions of modelling—such as model use, evaluation, revision, and meta-modelling knowledge—are absent at the explicit level.

At the same time, the term *model* appears in the curriculum with multiple meanings, most of which are unrelated to scientific modelling. This polysemy reduces the visibility of modelling as a specific scientific practice and makes it difficult to identify a coherent conceptualisation of modelling within the curriculum framework.

The findings also show that scientific activity is mainly framed in terms of inquiry processes focused on observation, experimentation, and data analysis. Within this framework, modelling does not appear as a differentiated practice, but rather as one of several possible actions embedded within broader inquiry dynamics. Although some elements of modelling can be interpreted as implicitly present—such as the use of predictions or the construction of explanatory "visions"—these are not explicitly articulated in terms of models or modelling practices.

Overall, this suggests that modelling in the Catalan curriculum is integrated as part of inquiry-based learning, rather than developed as a distinct epistemic practice. As a result, its role remains implicit and dependent on teacher interpretation, rather than being clearly defined and systematically supported as a core component of science education.

6. References

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