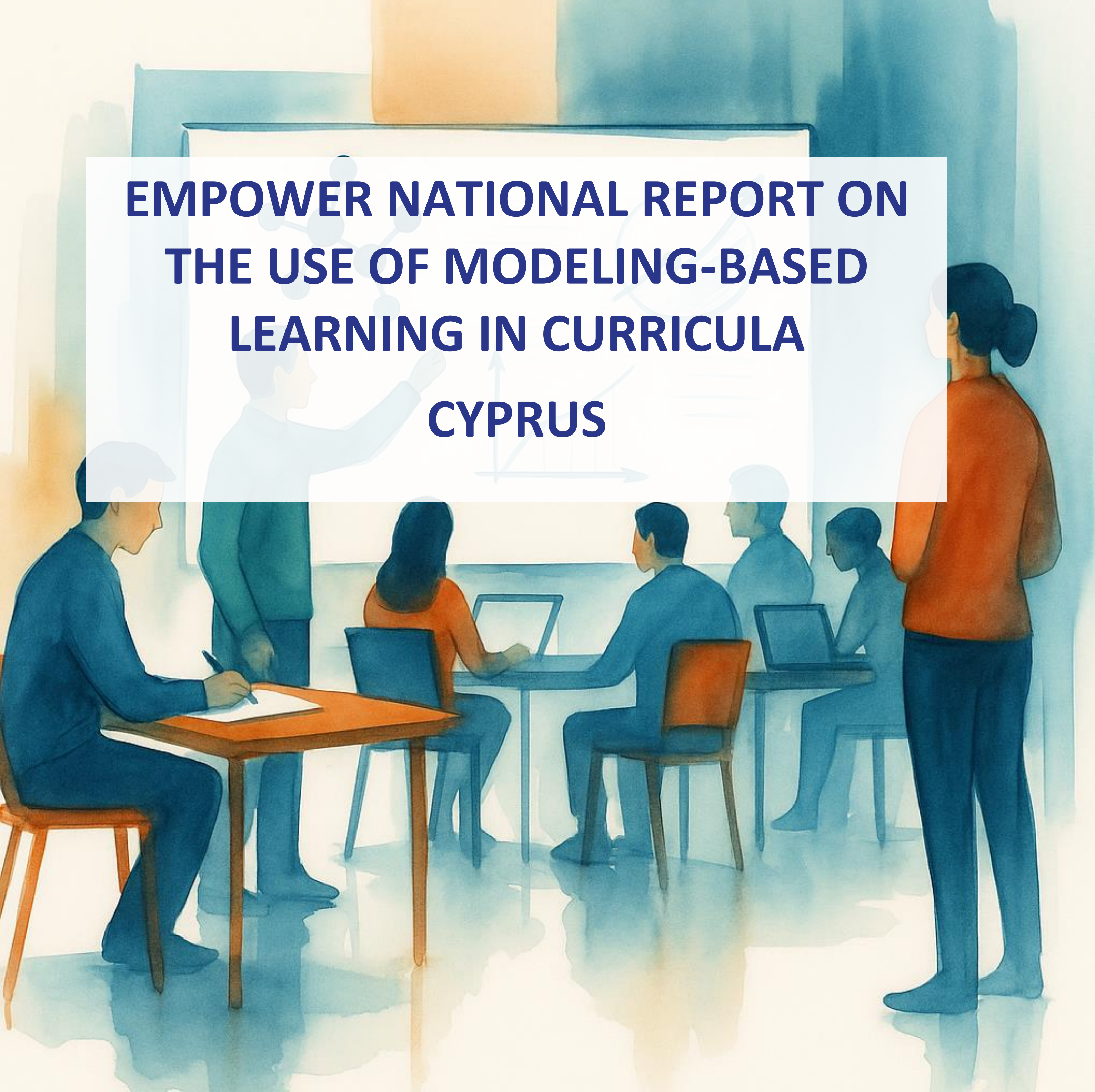
EMPOWER NATIONAL REPORT ON THE USE OF MODELING-BASED LEARNING IN CURRICULA

CYPRUS



2026

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

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1 Introduction

This report examines the integration of modelling-based learning (MbL) within the national biology curriculum of Cyprus for lower secondary education (Grades 7, 8, and 9). Within the national framework, curricular documents define the structure of science education by outlining core learning objectives, thematic content areas, and recommended instructional methodologies for each of the topics covered. The analysis is based on the teachers' handbooks developed by the Ministry of Education, which outline the core learning objectives, content areas, and recommended instructional approaches for each unit.

The Cyprus education system is characterized by a highly centralized structure, in which the Ministry of Education, Sport, and Youth is responsible for the design, development, and regulation of curricula. Educational policy and curriculum specifications for the public education system in Cyprus are determined at the national level, ensuring a uniform framework across all public schools. This centralized approach fosters consistency in curriculum implementation and facilitates the integration of shared pedagogical priorities.

Science education in Cyprus follows a structured progression across all educational levels. In primary education, the natural sciences are taught as an integrated subject, providing a general foundation for scientific literacy. In lower and upper secondary education, the sciences are organized into distinct disciplines – Biology, Chemistry, and Physics – each guided by its own specific curriculum. Within this framework, the biology curriculum defines subject-specific content and competencies, including the strategic use of models to enhance the understanding of scientific concepts.

Given this centralized and structured system, curriculum documents play an important role in shaping how MbL is represented and operationalized. Therefore, analyzing the integration of MbL within the biology curriculum provides critical insights into how modelling is conceptually framed and pedagogically supported within the Cypriot educational context.

2 Methodology

This report is based on a qualitative content analysis of the official biology curricula for lower secondary education, specifically Grades 7, 8, and 9 (student ages 13, 14, and 15).

The analysis was conducted using the official teacher guidebooks for Biology for each respective grade, as published by the Ministry of Education, Sport, and Youth of Cyprus. These materials are publicly accessible via the Ministry's official website and constitute the formal regulatory framework guiding classroom instruction. Each of the three documents was examined in its entirety, ensuring a comprehensive review of all relevant sections, including learning objectives, thematic content descriptions, and recommended instructional methodologies.

The analysis focused on identifying all references to modelling (such as models, modelling competence, modelling processes, or other model-related practices) within the curriculum texts. 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 1 below.

Table 1 *Coding scheme used for the analysis of modelling references*

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
	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

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.

A total of 215 references to MbL were identified across the analyzed curricula. Specifically, 54 (25%) instances were identified in Grade 7, 91 (42%) instances in Grade 8, and 70 (33%) instances in Grade 9. Each reference was coded according to all coding categories in the agreed scheme; in cases where a specific modelling strategy or category could not be clearly determined, the reference was classified as "not specified."

3 Background

The analyzed biology curriculum materials, as presented in the official teacher guidebooks for Grades 7, 8, and 9, follow a rigorous, structured format organized around discrete thematic units. Each unit encompasses clearly defined content areas, specific learning objectives, and recommended instructional methodologies designed to facilitate effective classroom implementation.

These guidebooks serve as a framework for instruction by delineating the topics to be addressed and proposing indicative activities and pedagogical approaches. These include references to fundamental scientific practices such as observation, experimentation, and, where applicable, the strategic use of models. Overall, the materials exhibit a content-oriented organization, supporting the delivery of biological concepts through an integration of subject matter and evidence-based teaching practices.

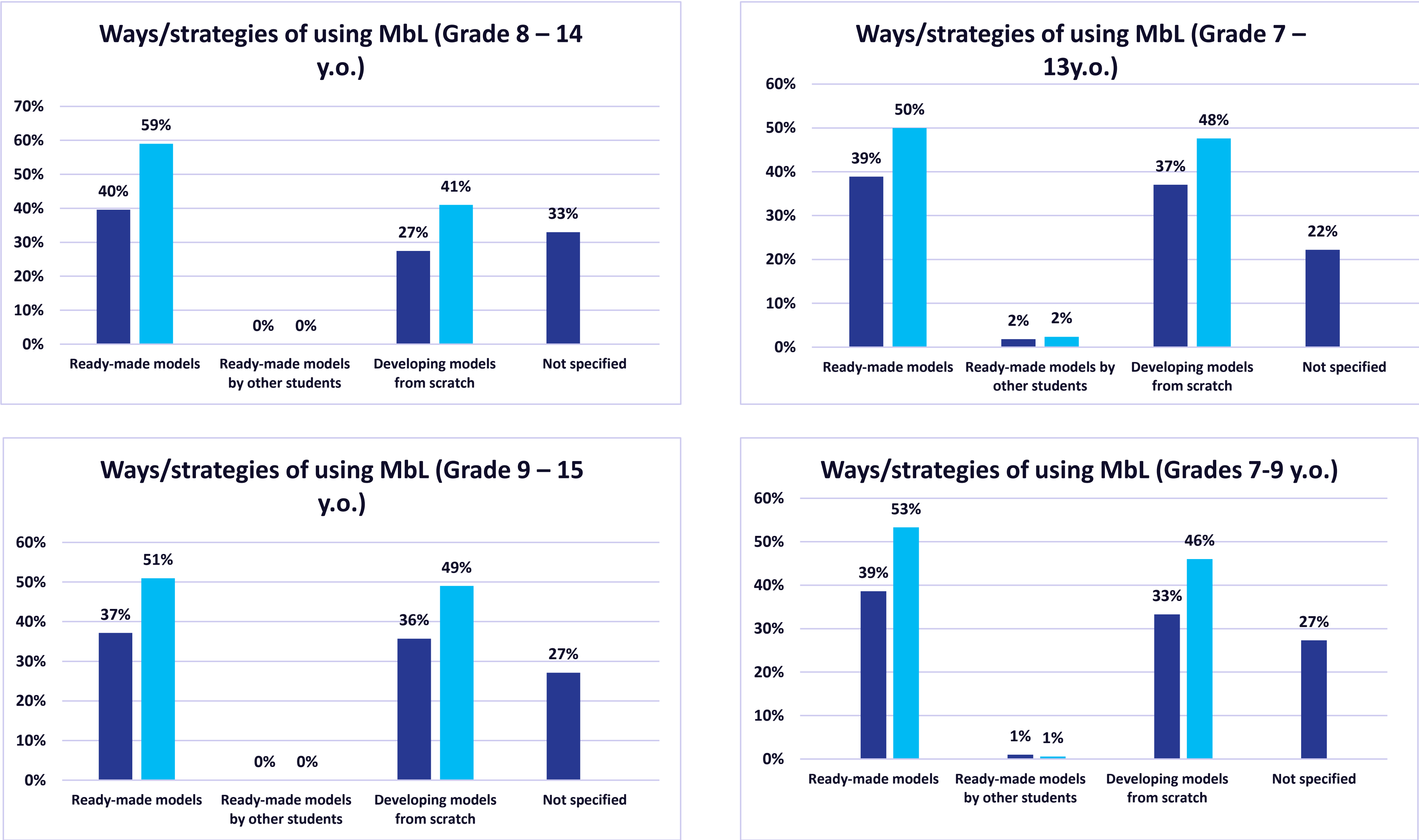
4 Findings

4.1 Strategies for using MbL

A primary finding concerns the lack of identification of the particular strategies employed for MbL; specifically, 27% of the identified cases (58 out of 215, 12 (22%) for Grade 7, 30 (33%) for Grade 8, and 19 (27%) for Grade 9) do not explicitly define the type of MbL strategy intended.

Across the three grades, ready-made models are proposed to be used as a strategy in MbL as much as developing models from scratch by students, while there is a lack of use of ready-made models by other students. This pattern is consistently observed across all three grade levels, although ready-made models tend to be slightly more prominent in most cases. Specifically, among the cases where strategies are explicitly defined, the use of ready-made models emerges as the dominant approach, accounting for 53% of the overall instances coded (50% in Grade 7, 59% in Grade 8, and 51% in Grade 9), while strategies involving the development of models from scratch account for 46% (48% in Grade 7, 41% in Grade 8, and 49% in Grade 9) **(see Figure 4.1).** In contrast, the use of ready-made models developed by other students is almost entirely absent, identified in approximately 1% of the overall cases and exclusively within the Grade 7 curriculum, where it accounts for 2% (n = 1). Overall, these findings indicate that the curricula prioritize the use of pre-constructed models over more student-centered, generative modelling practices, while also revealing a notable gap in the explicit articulation of modelling strategies.

Fig. 4.1 *Strategies for using MbL*



4.2 Definitions of modelling competence

The analysis reveals that explicit definitions of modelling competence are largely absent across the lower secondary Biology curricula (Grades 7–9). Out of a total of 215 identified instances of MbL, only 11 cases explicitly define modelling competence, representing approximately 5% of the total sample. At the grade level, the frequency of explicit conceptualization also remains low. In Grade 7, only 2 out of 54 instances (4%) provide a clear definition of modelling competence. Similarly, in Grade 8, 8 out of 91 instances (9%) were found to include specified definitions. In Grade 9, explicit definitions are almost entirely non-existent, with only 1 instance identified out of 70 (approximately 1.5%). Consequently, the vast majority of references to modelling competence—approximately 95%—fall under the category of "not specified," indicating that the curricula rarely offer a concrete conceptual framework for this competence. Overall, these findings highlight a substantial gap in the formal definition of modelling competence within the analyzed documents.

4.3 Significance of models in the natural sciences

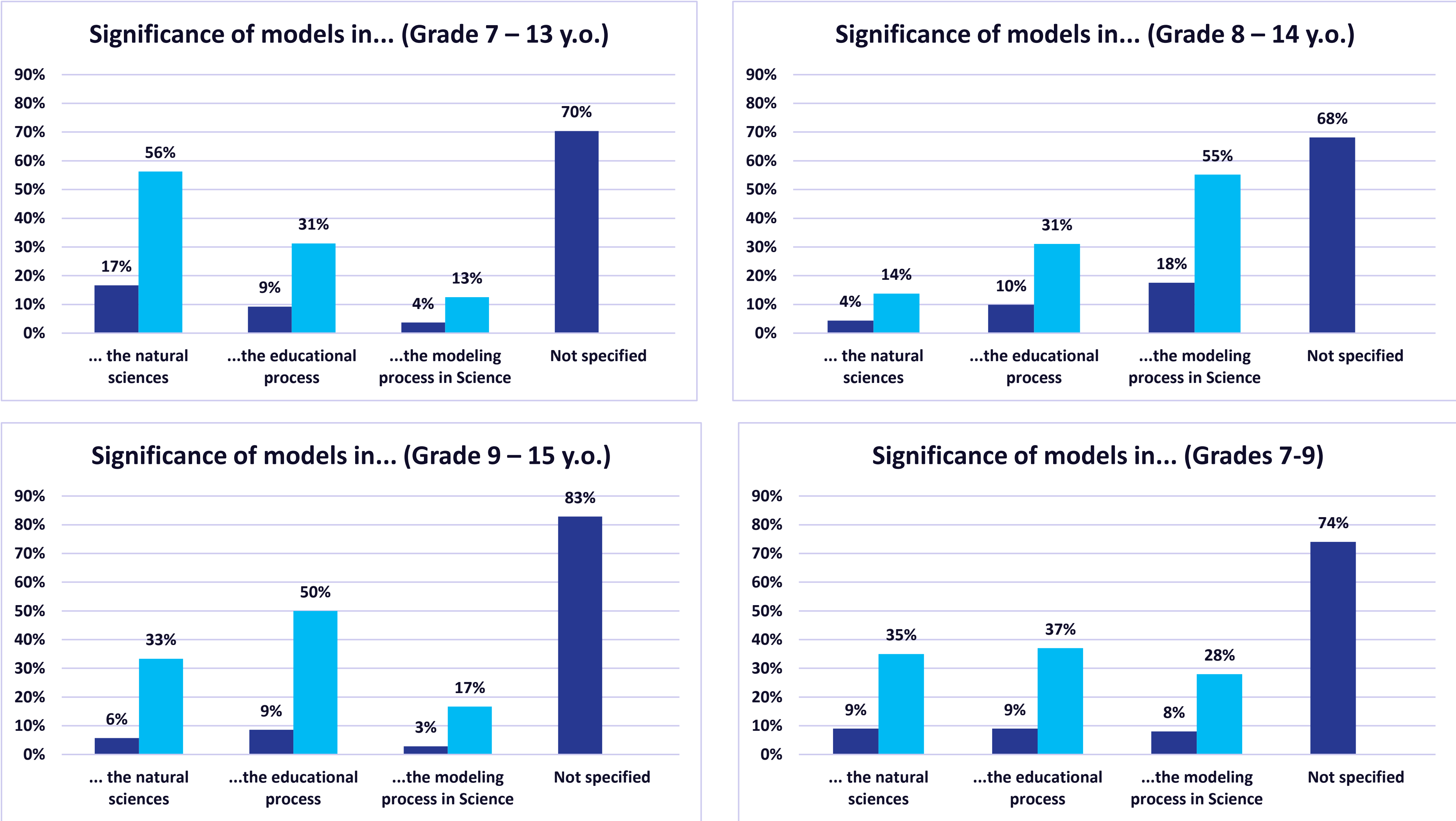
Figure 4.3 shows how the significance of models is conceptualized across grade levels, alongside a consistently high proportion of unspecified references.

In Grade 7, models are primarily associated with the natural sciences (56% of specified instances), followed by the educational process (31%) and the modelling process in science (13%). However, 70% of all references remain unspecified. In Grade 8, the modelling process in science becomes the dominant category (55%), while the educational process (31%) and the natural sciences (14%) are less prominent. The majority of cases (68%) remain unspecified. In Grade 9, emphasis shifts to the educational process (50%), followed by the natural sciences (33%), while the modelling process in science is significantly underrepresented (17%). Unspecified cases reach their peak at 83%.

Across Grades 7–9, 74% of all references are classified as unspecified. Among the minority of explicitly defined cases, the educational process (37%) and the natural sciences (35%) are the most frequent, while the modelling process in science accounts for 28%.

These patterns indicate that, although the perceived significance of models fluctuates across grade levels, it is rarely articulated explicitly.

Fig. 4.3 *Significance of models in the Natural Sciences*



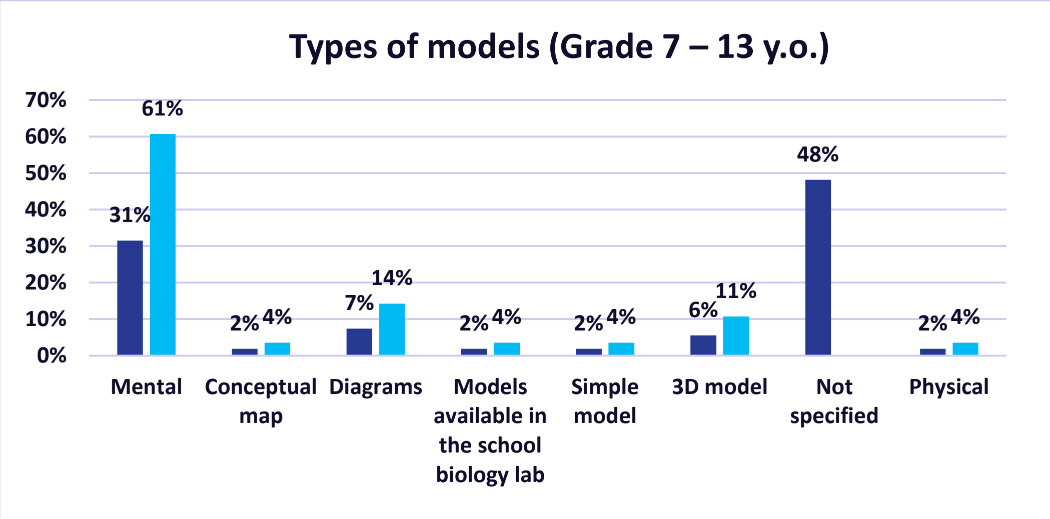
4.4 Types of models

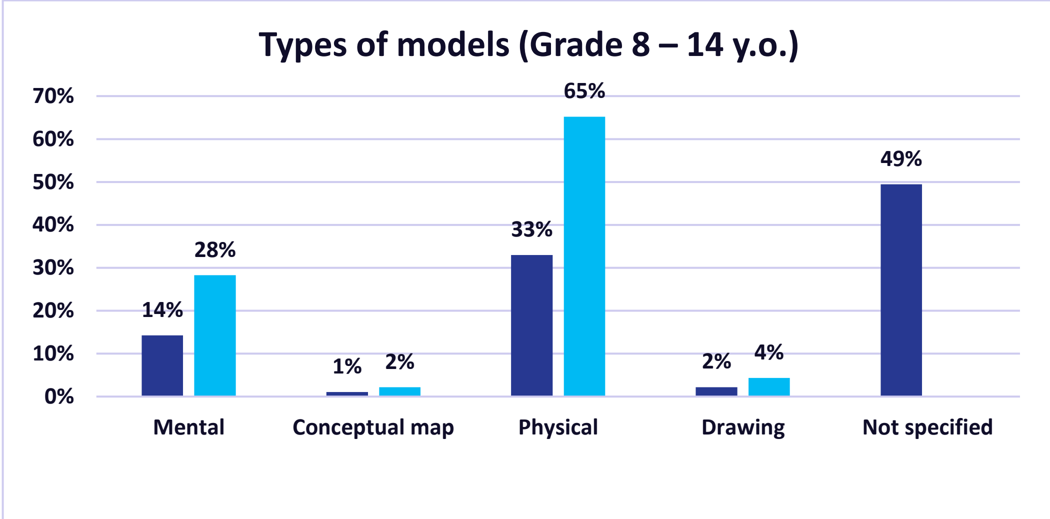
Figure 4.4 presents the distribution of model types across grade levels, highlighting a notable variation in pedagogical emphasis alongside a consistently high proportion of unspecified references.

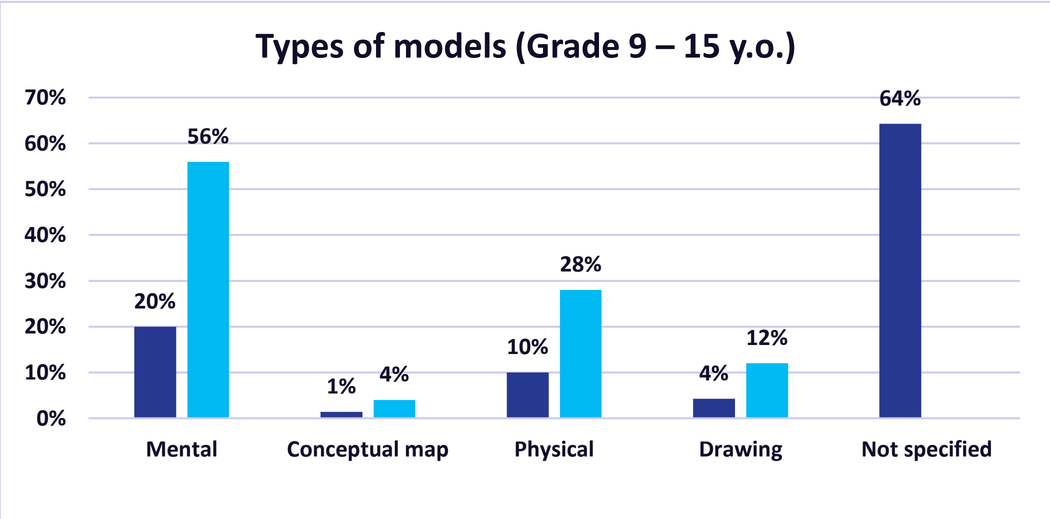
In Grade 7, mental models emerge as the most frequently identified category among specified instances, accounting for 61%, followed by diagrams at 14% and 3D models at 11%, while all other categories remain below 5% (which are conceptual maps, simple models, and physical models). 48% of the total cases in this grade do not specify a model type. In Grade 8, physical models become the dominant specified category at 65%, followed by mental models at 28%, whereas conceptual maps and drawings remain minimally represented at 2% and 4%, respectively. The proportion of unspecified cases in Grade 8 remains significant at 49%. In Grade 9, mental models return as the most prominent category at 56%, with physical models following at 28% and drawings at 12%, while conceptual maps remain limited to 4%. Notably, this grade level exhibits the highest degree of ambiguity, with unspecified references reaching 64%. When examining the aggregated data across Grades 7–9, 54% of all curricular references are classified as “not specified”. Among the explicitly defined instances, mental models are the most frequent (48%), followed by physical models (32%), while conceptual maps account for only 3% of the total. The remaining categories—3D models, diagrams, drawings, simple models, models available in the school biology lab, and other model types—each account for 2% or less.

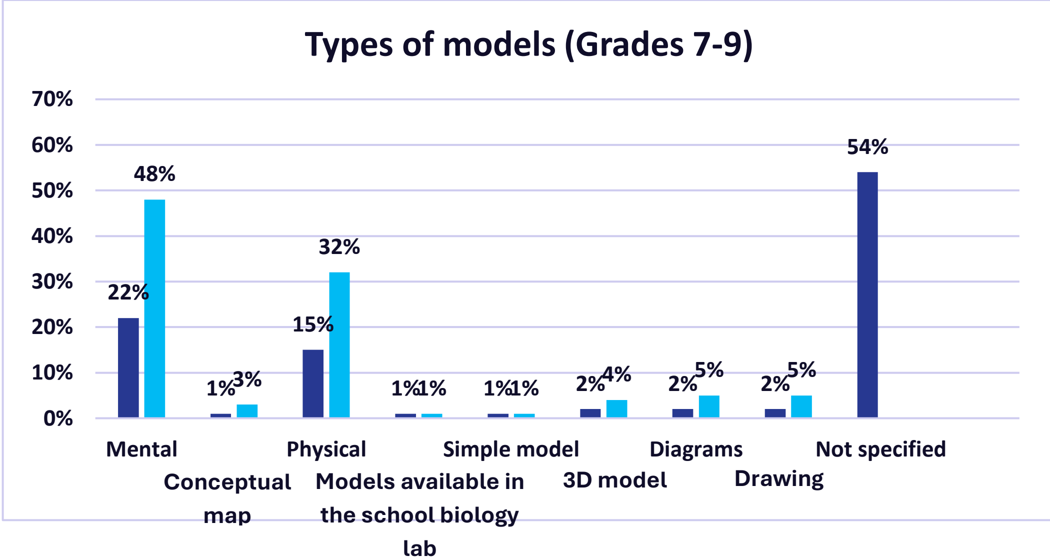
Overall, these findings indicate that while a range of model types is referenced, explicit identification and differentiation remain limited, with a clear concentration on mental and physical models.

Fig. 4.4 *Types of Models*









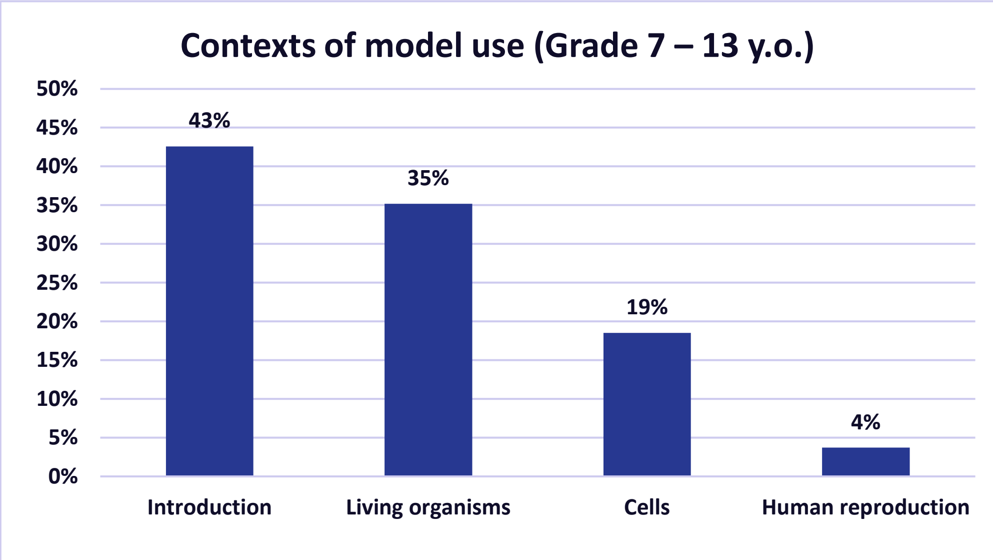
4.5 Contexts of model use

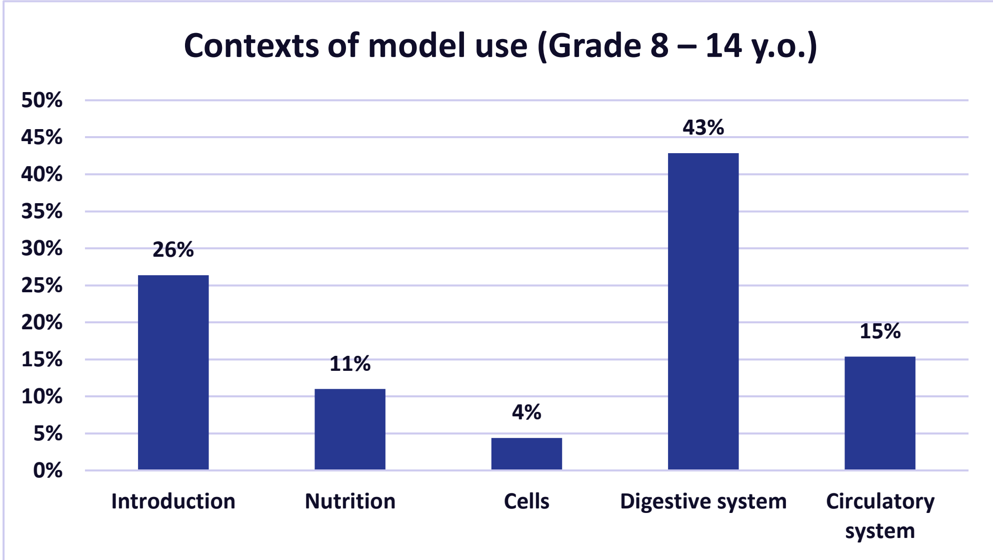
The analysis of the contexts in which models are utilized across lower secondary curricula (Grades 7–9) reveals a distribution that evolves across grade levels, reflecting a transition from foundational concepts to more specialized biological applications.

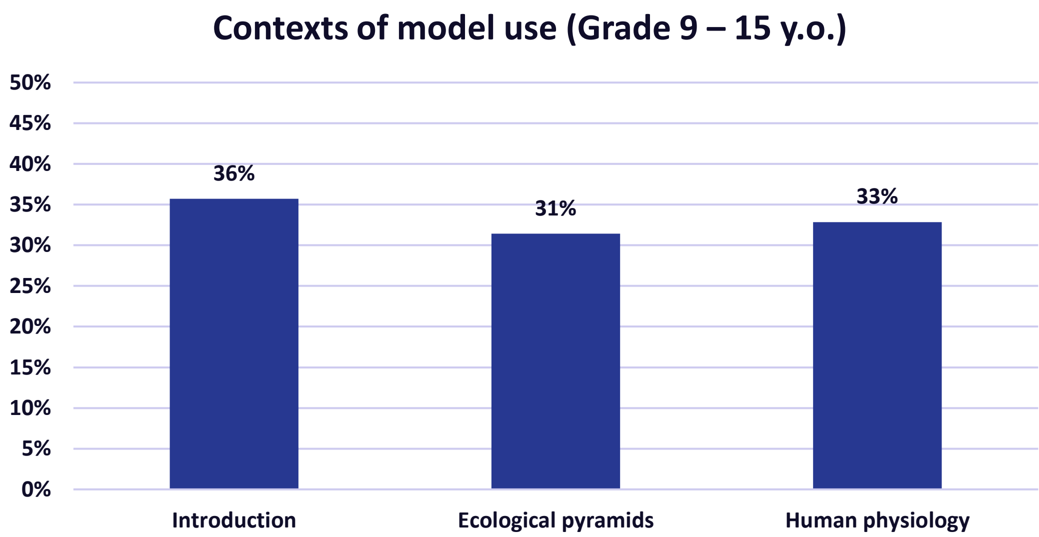
In Grade 7, model use is primarily situated within introductory and fundamental biological contexts. The category “Introduction” accounts for the highest proportion of instances (43%), followed by “Living organisms” (35%) and “Cells” (19%). References to reproduction are minimal, representing only 4%. In Grade 8, the “Digestive system” emerges as the dominant context for model use, accounting for 43% of instances. This is followed by “Introduction” (26%) and the “Circulatory system” (15%). Other contexts, such as “Nutrition” (11%) and “Cells” (4%), appear less frequently. In Grade 9, the application of models is distributed more evenly across three primary contexts: “Introduction” (36%), “Human physiology” (33%), and “Ecological pyramids” (31%) **(see Figure 4.5).**

Given that, with the exception of the introduction, each context is represented only in a single grade, for the context of model use, we do not have a comparison amongst grades. Also, the coding was applied in all the cases that modeling related terms were identified, and thus, there is no cases that fall under the not specified category.

Fig. 4.5 *Contexts of Model use*







4.6 Modelling practices

An examination of modelling practices across lower secondary curricula (Grades 7–9) highlights a strong concentration on the use and selection of models, while practices involving evaluation and revision appear considerably less.

Considering only the instances in which modelling practices are explicitly specified, the distribution in Grade 7 shows that the use or selection of models constitutes the largest share (33%), followed by model creation (28%) and model revision (28%), while model evaluation accounts for a smaller proportion (11%). In parallel, a substantial majority of total cases (67%) do not specify the type of modelling practice.

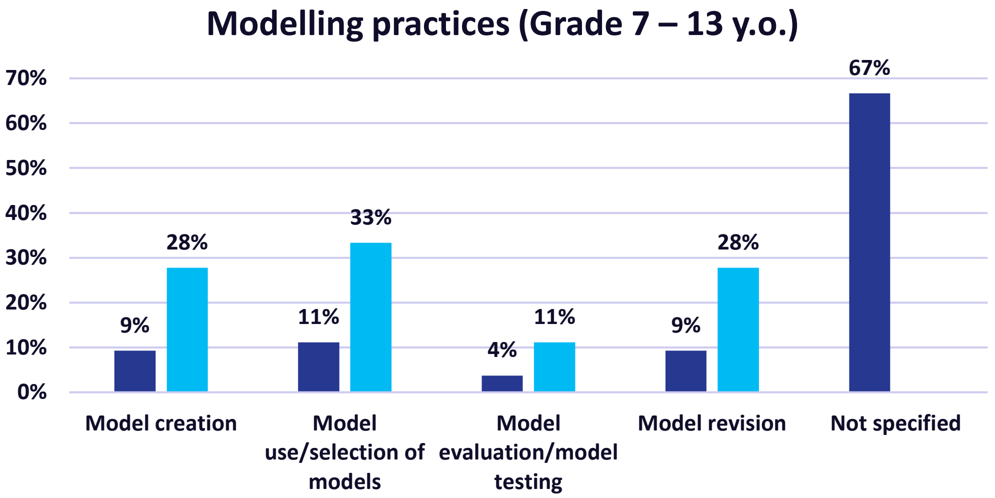
A similar pattern is observed in Grade 8. Among the identified instances, model use/selection becomes even more prominent, accounting for 61%, followed by model creation (32%). Model revision (5%) and model evaluation (3%) remain marginal. At the same time, a considerable proportion of references (58%) fall under the “not specified” category.

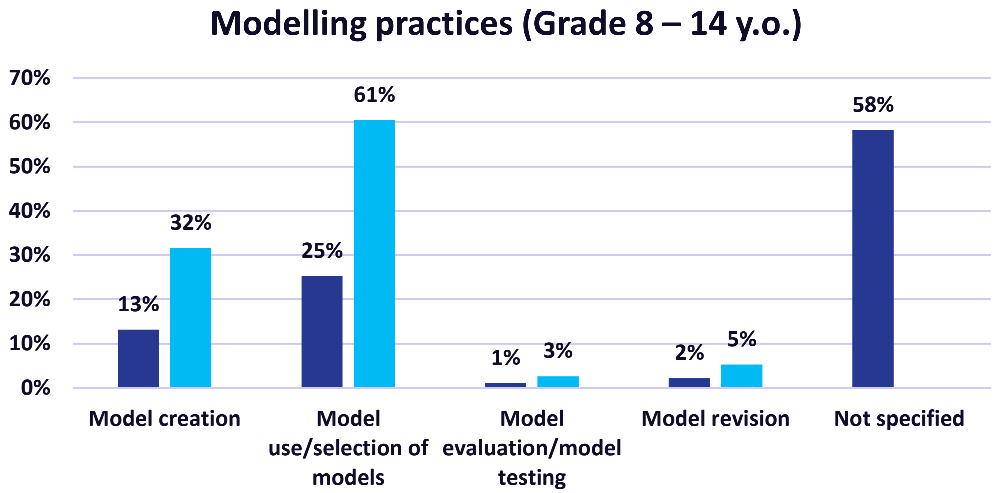
In Grade 9, the distribution of specified instances again demonstrates the dominance of model use/selection (51%), followed by model creation (23%). Model evaluation (14%) and model revision (11%) remain secondary in comparison. The proportion of unspecified cases continues to be high, reaching 50%.

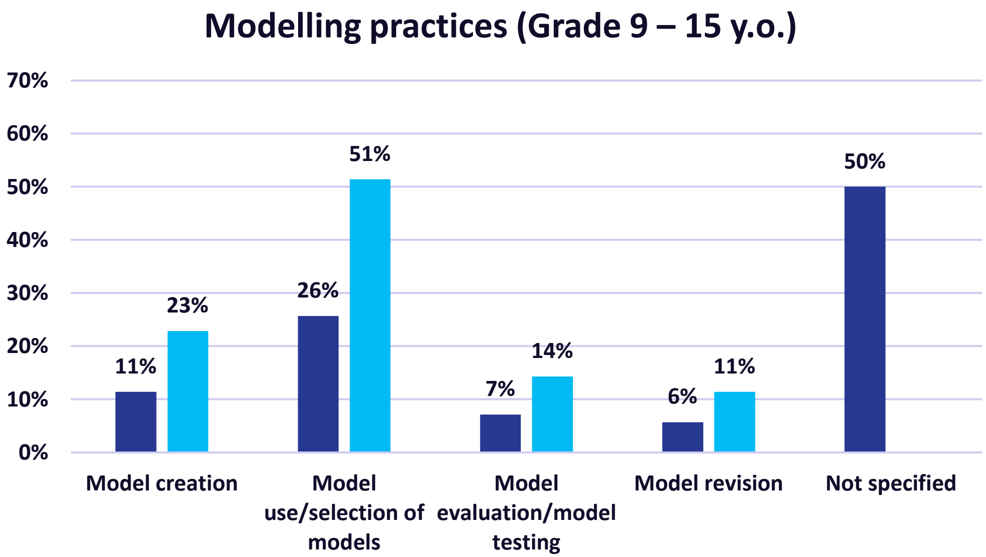
When considering the aggregated data across all grades (Grades 7–9), more than half of the references (58%) are not explicitly assigned to a specific modelling practice. Focusing on the subset of cases where practices are defined, model use/selection emerges as the most prevalent category (48%), followed by model creation (28%), while model revision (15%) and model evaluation (9%) account for significantly smaller proportions **(see Figure 4.6).**

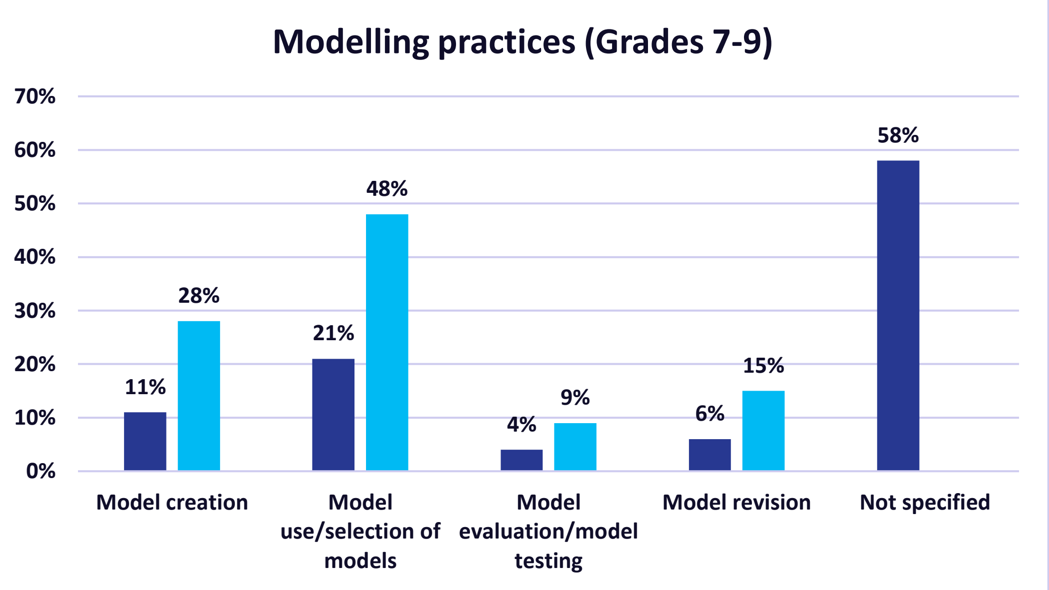
Overall, these results point to a systemic imbalance in the representation of modelling practices, highlighting a clear preference for the application of existing models over the critical processes of evaluation and revision, which may limit student engagement with the full modelling cycle.

Fig. 4.6 *Modelling Practices*









4.7 Meta-modelling knowledge

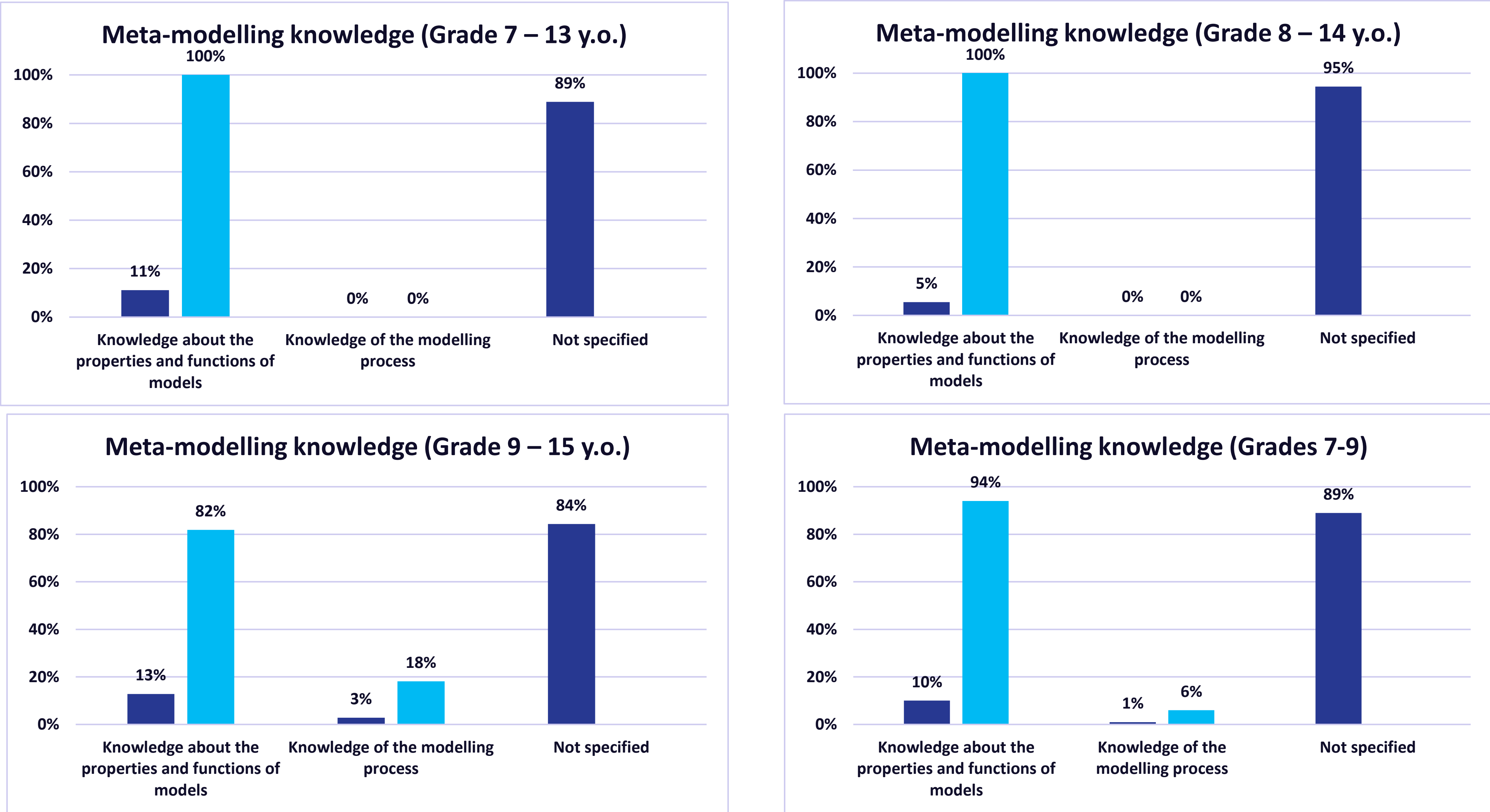
The analysis of meta-modelling knowledge across lower secondary curricula (Grades 7–9) indicates that explicit references remain highly restricted, with the vast majority of instances lacking clear specification.

In Grade 7, only a small proportion of references relates to knowledge about the properties and functions of models (11%), while no instances are associated with knowledge of the modelling process. Consequently, the majority of cases (89%) are classified as "not specified". A similar pattern is observed in Grade 8, where references to knowledge about the properties and functions of models account for just 5%, and again, no instances address knowledge of the modelling process. The proportion of unspecified cases is particularly high in this grade level, reaching 95%. In Grade 9, a slightly broader distribution is evident. References to knowledge about the properties and functions of models account for 13%, while knowledge of the modelling process is identified in a small proportion of cases (3%). Nevertheless, the majority of instances (84%) remain unspecified.

When considering the aggregated data across all grades, 89% of references fall under the "not specified" category. Among the subset of explicitly defined instances, knowledge about the properties and functions of models clearly dominates (94%), whereas knowledge of the modelling process accounts for a very limited proportion of only 6% **(see Figure 4.7).**

Overall, these findings demonstrate that meta-modelling knowledge is rarely articulated explicitly within the analyzed curricula. Where it is addressed, the emphasis is placed primarily on understanding the characteristics and functions of models, while aspects related to the dynamic modelling process itself remain largely underrepresented.

Fig. 4.7 *Meta-modelling Knowledge*



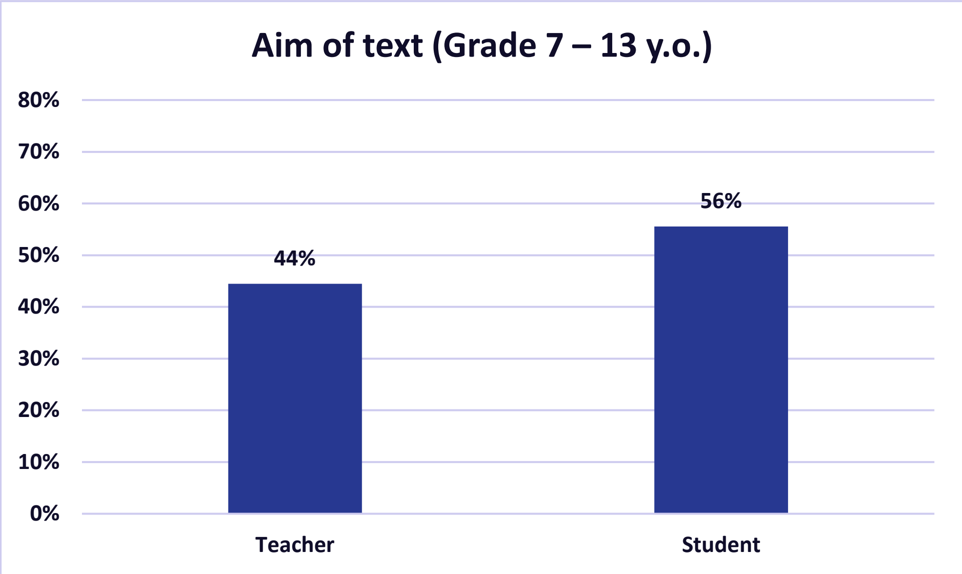
4.8 Aim of text

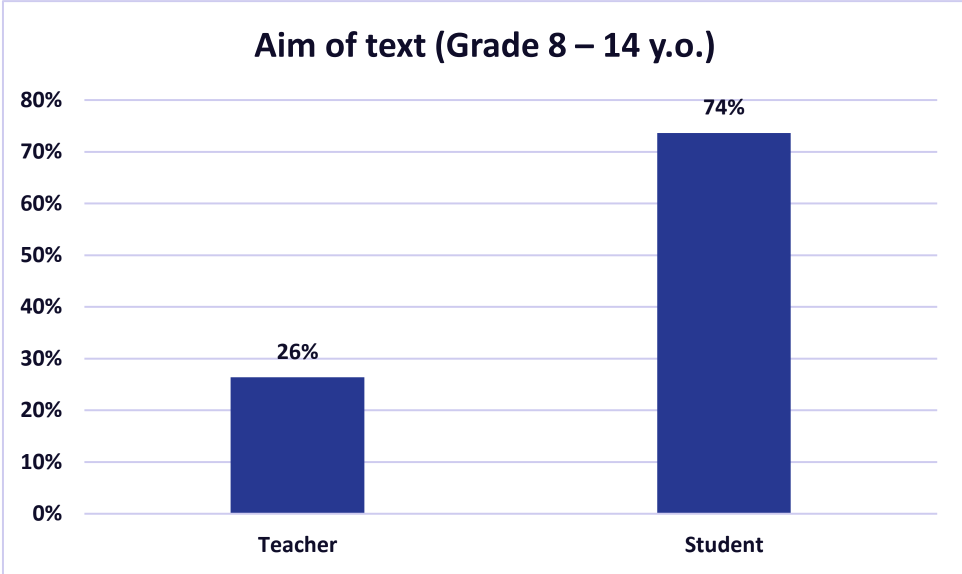
Figure 4.8 illustrates the distribution of modelling references according to their intended audience, providing a comparative analysis between references directed at the teacher and those specifically aimed at the student.

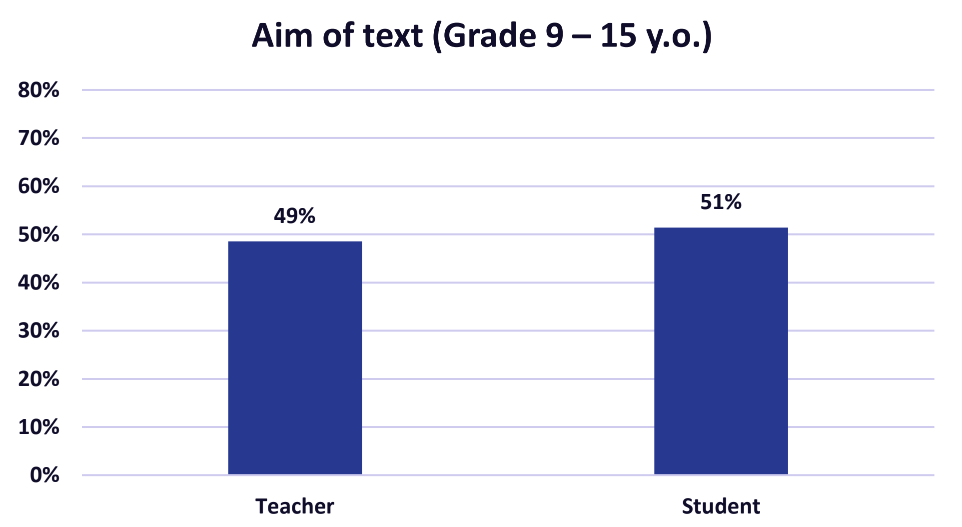
In Grade 7, the distribution appears relatively balanced, although student-oriented references exhibit a slightly higher frequency at 56%, compared to 44% for teacher-oriented content. In Grade 8, the focus shifts heavily toward the student, with references reaching 74%, while those directed at the teacher drop to 26%. In contrast, in Grade 9, 51% of references targeted at students and 49% at teachers.

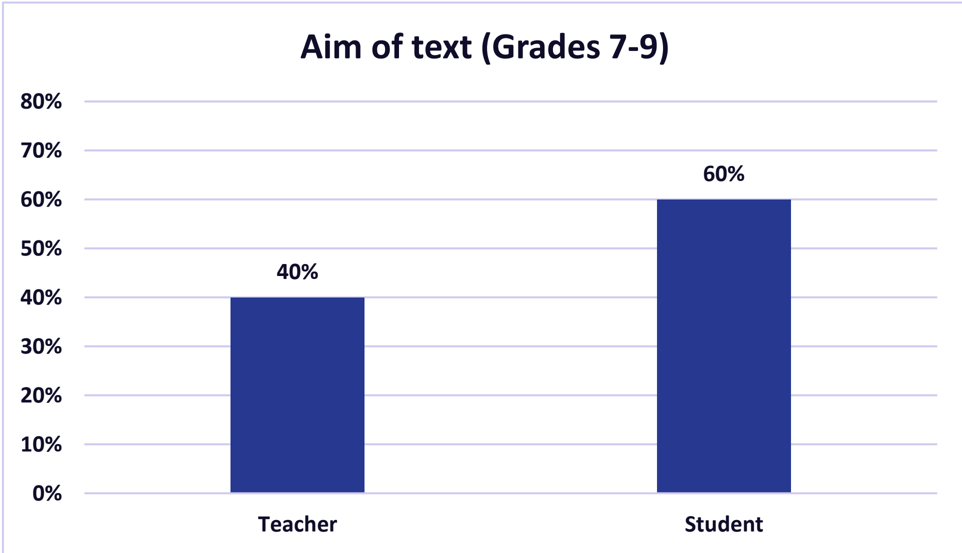
Viewing the data as an aggregate across Grades 7–9, student-oriented references constitute the 60%, while teacher-oriented references account for the remaining 40%.

Fig. 4.8 *Aim of text*









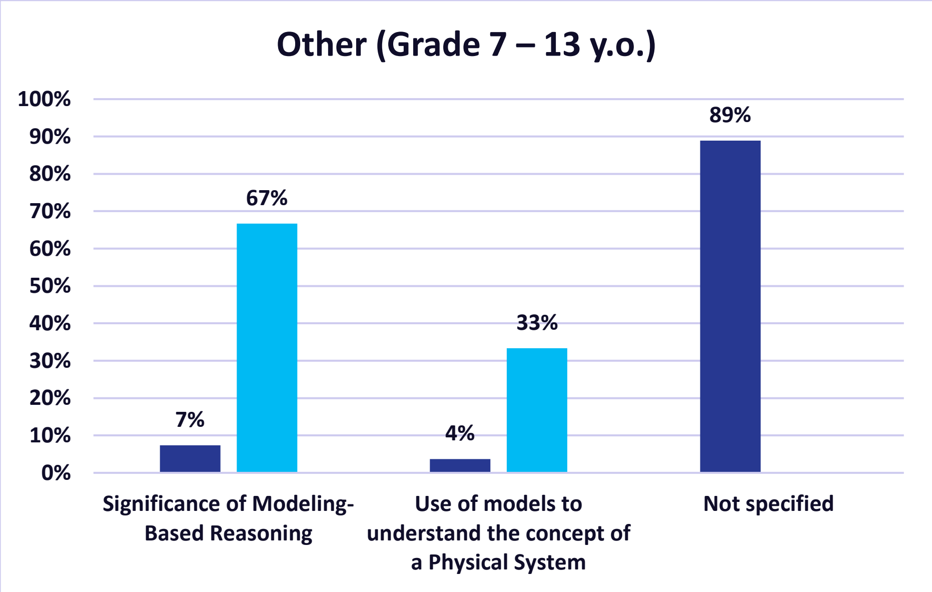
4.9 Other

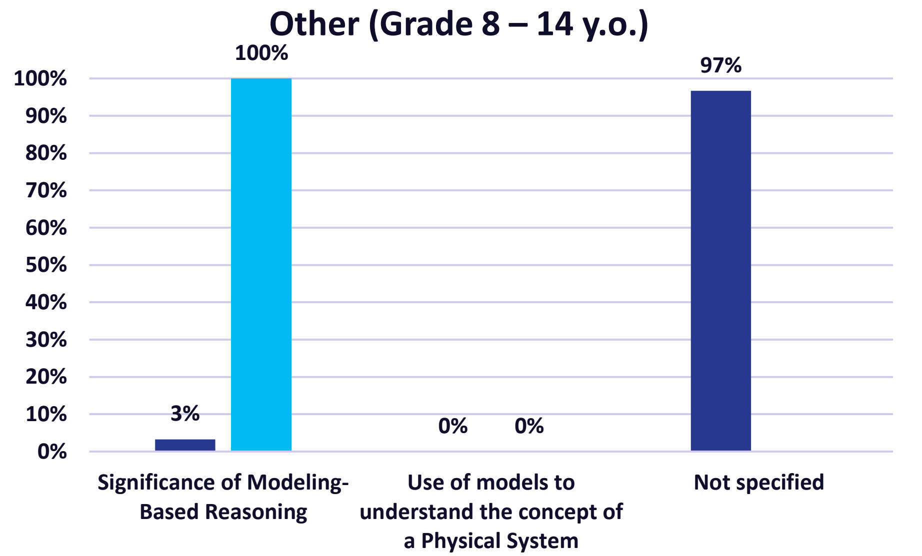
Figure 4.9 illustrates the distribution of references classified under the category "Other," providing a comparative overview of references to the significance of modelling-based reasoning and the use of models to understand physical systems, alongside those designated as "not specified."

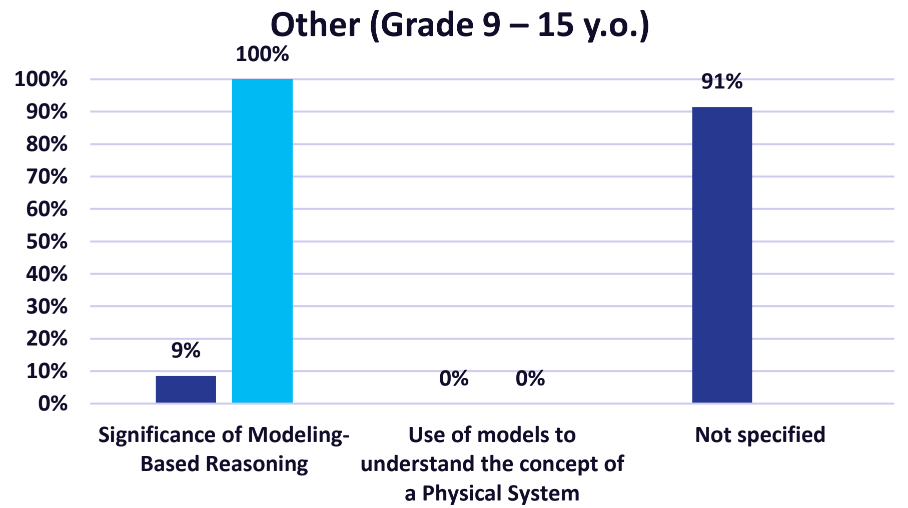
In Grade 7, the explicitly defined instances are divided between the significance of modelling-based reasoning (67%) and the understanding of physical systems (33%). In Grade 8, modelling-based reasoning accounts for the entirety (100%) of the references, with no instances recorded for physical system understanding. A similar pattern is found in Grade 9, where specified instances are again exclusively associated with modelling-based reasoning (100%).

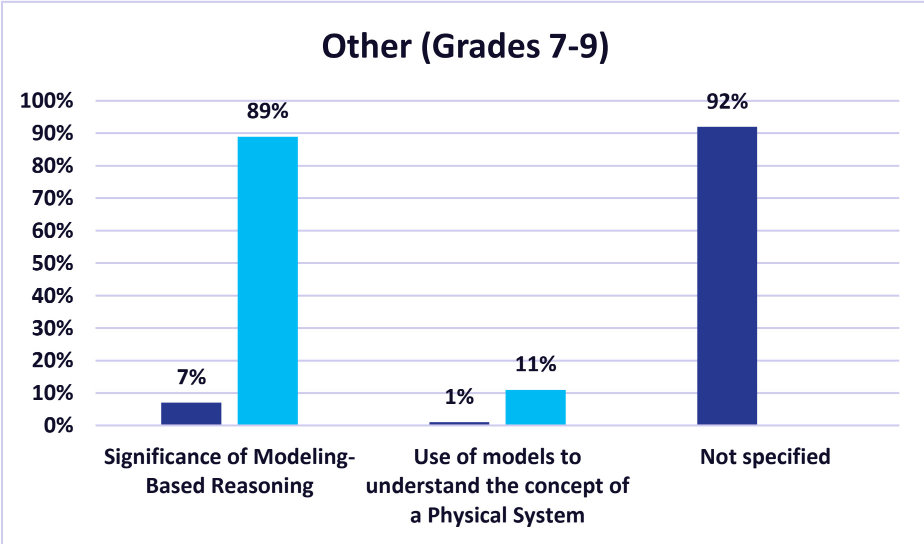
On an aggregate level across Grades 7–9, a striking 92% of all references fall within the "not specified" category. Among the limited instances where specification is provided, modelling-based reasoning emerges as the primary focus at 89%, whereas references related to understanding physical systems remain statistically scarce at 11%.

Fig. 4.9 *Other*


Other (Grade 7 – 13 y.o.)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
7%
67%
4%
33%
89%
Significance of Modeling-Based Reasoning
Use of models to understand the concept of a Physical System
Not specified


Other (Grade 8 – 14 y.o.)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
3%
100%
0%
0%
97%
Significance of Modeling-Based Reasoning
Use of models to understand the concept of a Physical System
Not specified


Other (Grade 9 – 15 y.o.)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
9%
100%
0%
0%
91%
Significance of Modeling-Based Reasoning
Use of models to understand the concept of a Physical System
Not specified


Other (Grades 7-9)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
7%
89%
1%
11%
92%
Significance of Modeling-Based Reasoning
Use of models to understand the concept of a Physical System
Not specified

5 References

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