Electronic supplementary material

Coding scheme

Category	Subcategory	Description	Examples/Indications
Year	2020 -2024		
Continent	Country	Countries of the participating authors' affiliations. If several authors from one county participated, the country was counted only once. If authors from different countries contributed to a publication, each country was credited with one publication. No distinction was made based on the authors' positions (e.g., first or second author).	
Participants	1 – Early childhood, Kindergarden or Pre-school	Since there is no international consensus on grade labels (e.g. grades assigned to high school), we based our coding on the participants' actual year levels. If multiple populations were targeted, each population was coded separately, yielding 127 populations across 108 publications reviewed.	
	2 - Year levels 1-6 ("Elementary school")		
	3 - Year levels 7-10 ("Secondary school")		
	4 - Year levels 11-13 ("upper secondary school")		
Research paradigma	Research paradigma describes, whether qualitative, quantitative or mixed research methods were used		
	1 - Qualitative		
	2 - Quantitative		
	3 - Mixed method	If qualitative and quantitative methods were used, the study was assigned to a mixed methods research paradigm	
Design	Experimental study Randomized control trail	EX	Differentiation of study designs based on Jha (2024).

	Quasi Experiment	QEX	If multiple studies with different study designs were reported, each design was coded separately, yielding 118 study designs across 108 publications reviewed.
	Design-Based Research	DBR	
	Descriptive study	DS	
	Case study	CS	
"Perspective": Modelling goals	Aims or reasons why it is important to teach modelling/learn to solve modelling problems/ use applications in school		
	p - pragmatic	Modelling to help students to understand and master real world situations.	"Students should be able to use the mathematics they learn in school in everyday life." (Tran et al., 2020)
	f - formative	Modelling to foster competencies. In particular modelling competency but also other competencies (i.e. argumentation competency).	"Mathematics education researchers have suggested using mathematical modelling as a vehicle for eliciting algorithmic thinking." (Lehmann, 2024)
	ce - cultural emancipatory	Support critical thinking about the role of mathematics in society, about the role of and nature of mathematical models and the function of mathematical modelling in society.	"Simply stated, teachers of mathematics not only work to develop students' mathematics content understanding, they must also empower students to see how mathematics can be used to influence and make sense of the world" (Edelen et al., 2020)
	cm - cultural mathematics	Modelling to structure both mathematical and non-mathematical fields though the application of mathematical tools.	„science as modelling perspective" (Dickes) "students can also develop meta-modeling knowledge (Schwarz and White 2005)—i.e., knowledge about the nature and purpose of scientific work—

			because, they may learn to identify abstract representations as models and demonstrate how models can be used to predict and explain scientific phenomena.“ (Dickes et al., 2020)
	pm – psychological motivation and sense-making	Modelling as an activity which motivates and naturally allows students to develop the mathematics needed to make sense of real-world situations.	“Another modeling goal incorporates real-life contexts “to motivate the need for learning mathematics” (Jung & Brady, 2023)
	pl - psychological learning	Structure learning processes and mathematical content, to better understand it and to retain it longer.	“Modelling can provide rich tools for fostering integrated and real-world STEM experiences, providing opportunities for students to express and develop disciplinary understandings across the STEM fields” (English, 2023b)
	mix – Mixed goals	Authors refer to several goals, it is not possible to distinguish which was focused	
	No or other	or no goal mentioned	E.g. “understand modelling processes” “foster interdisciplinarity” Huffmann (2021)
“Perspective”: Modelling problems	Examples of modelling problems that were used in the study		
	Aut - Authentic	Concrete authentic examples (e.g. from shopping, newspapers, taxes, traffic flow, wind park planning, air fare calculation, …); examples that show students how	“[We] designed a learning situation contextualised in a realistic and authentic archaeological context which promoted the development of inquiry and modelling skills for

		strongly mathematics shapes the world.	its solving." (Falcó-Solsona et al., 2024)
	CR - Cognitively rich	Cognitively rich problems. In particular when they are accompanied by meta-cognitive activities.	Also tasks constructed to measure modelling (sub-)competencies
	ER - Epistemological rich	Problems that shed light on mathematics as a scientific discipline.	
	Mot - Motivating	Interesting examples for motivation or illustration purposes, to make mathematics better marketable for students (might also be dressed-up or whimsy problems).	"Although this context does not present a realistic real-world problem situation per se, it mimics and captures many central aspects of real-world modelling problems, such as an ecologist's problem to estimate wildlife population sizes." (Ärlebäck & Frejd, 2021)
	MR- Mathematical rich	Mathematically rich problems that serve the purpose to make certain mathematical topics better comprehensible.	"The tasks follow the same structure and the mathematical goal in terms of learning trajectories is to conceptualize function as a covariational relationship between two quantities. The hypothetical learning trajectories from simple to more advanced conceptualizations are: (I) intuitive approach to covariation through manipulatives; (II) covariation between attributes of quantities; (III) covariation of magnitudes; (IV) covariation of variables; and (V) rate of change." (Kafetzopoulos & Psycharis, 2022)

	No modelling problem presented or mixed characteristics	No example of a modelling problem presented, and no important problem characteristics mentioned or various characteristics without highlighting which one is the most important or the primary focus	
Modelling framework	The theoretical framework (e.g. modelling cycle) that was used in the study		
Self-reported perspectives	Inductively coded		
Modelling Framework cycle	Referenced modelling cycle or framework Inductively coded		

Conceptual frameworks that draw on the modelling cycle used in the publications

Modelling framework	*n*	%
Blum and Leiss (2007)	18	17
Lesh and Doerr (2003)	9	8
Blum and Borromeo Ferri (2009); Kaiser and Stender (2013)	4 each	4 each
Kaiser (2007); Stillman et al. (2007)	2 each	2 each
Borromeo Ferri (2006); Buchholtz (2021); Doğan et al. (2019); Daher and Shahbari (2015); G. Greefrath and Vorhölter (2016); G. Greefrath et al. (2018); Lagrange (2014); Lesh and Harel (2003); Lu and Kaiser (2022); Mayes and Myers (2015); Mooney and Swift (1999); English (2023a); Niss (2010); OECD (2009); Rodriguez (2007); Stillman et al. (2013); Zbiek and Conner (2006)	1 each	1 each
Mixed modelling framework	24	22
No modelling framework	23	21
Frameworks from other fields of research applied to modelling	5	5

List of publications included in the systematic literature review

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