Competence facets and task types for graphical modeling

Competence facets	Task type (central / product-related)	Task type (optional)	Task type (marginal / process-related)	Further recommendations
Model understanding & interpreting				
MU 1.01 Learners are able to explain basic key terms and concepts of modeling (such as model, principles of model building, definition and modification of models, metamodels).	Comprehension task	Case study		
MU 1.02 Learners are able to explain and compare concepts of modeling structures or behavior (i.e., static and dynamic aspects).	Comprehension task, Interpreting model content	Case study	Interpreting model content, Applying a modeling language	
MU 1.03 Learners are able to explain the strengths and weaknesses of specific modeling languages or model types for a specific purpose.	Comprehension task	Applying a modeling language		
MU 1.04 Learners are able to distinguish between different areas of modeling (e.g., software engineering, database design, business process modeling) and describe them in a differentiated manner.	Comprehension task			In addition, students should become familiar with the various area of modeling throughout their studies.
MU 1.05 Learners are able to explain possible modeling purposes in terms of the intended use or implementation of models (e.g., for code generation, simulation, or organizational design).	Comprehension task	Case study		
MU 1.06 Learners are able to explain the principle of abstraction (generalization/specialization) and levels of abstraction.	Comprehension task			
MU 1.07 Learners are able to explain criteria for evaluating model quality (e.g., syntax, semantics, pragmatics according to relevant frameworks such as SEQUAL).	Comprehension task	Check pragmatic quality of a model		
MU 1.08 Learners are able to explain syntactical rules of the modeling language(s) under consideration.	Comprehension task	Syntactical error finding	Error finding based on a model and a corresponding text, Error finding based on two corresponding models	
MU 1.09 Learners are able to explain the meaning (semantics) of existing model elements and their relationships/connections in respect to the modeling language(s) under consideration.	Comprehension task, Identifying model elements	Interpreting model content (without context)	Error finding based on a model and a corresponding text, Error finding based on two corresponding models	
MU 1.10 Learners are able to interpret and explain the content of a given model.	Identifying model elements, Interpreting model content, Model translating		Error finding based on a model and a corresponding text, Error finding based on two corresponding models, Problem-solving based on a given model, Check formal model properties, Check pragmatic quality of a model, Compare models, Check suitability of a model, Model completing, Model adjusting, Peer feedback	

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MU 1.11 Learners are able to explain the possibilities and limitations of graphical modeling.	Comprehension task	Case study		
MU 1.12 Learners are able to explain formal properties of models (e.g., properties of Petri nets).	Comprehension task	Model building based on (formal) properties or criteria; Development of analysis questions		
MU 1.13 Learners are able to identify individual model elements in an existing model on the basis of the notation.	Identifying model elements			
MU 2.01 Learners use the information contained in a given model to solve a problem or situation in the corresponding application domain.	Problem-solving based on a given model	Case study		
MU 3.01 Learners are able to check a given model in terms of formal properties.	Check formal model properties, peer feedback	Error finding based on two corresponding models	Model completing, Model adjusting	
MU 3.02 Learners are able to check and evaluate the suitability of a given model for the description of a specific scenario and in relation to a specific modeling purpose.	Check suitability of a model, Compare models, peer feedback		Error finding based on a model and a corresponding text	
MU 3.03 Learners are able to check the correctness of a given model in terms of the syntax of the modeling language used.	Syntactical error finding, Peer feedback		Model adjusting	
MU 3.04 Learners are able to check the semantic correctness and completeness of a given model in relation to the considered scenario.	Error finding based on a model and a corresponding text, Compare models, Model adjusting, Peer feedback	Model completing	Interpreting model content, Error finding based on two corresponding models, Model building based on another graphical model, Model adjusting, Check suitability of a model	
MU 3.05 Learners are able to check the pragmatic quality (comprehensibility, unambiguity) of a given model.	Check pragmatic quality of a model, Peer feedback			
MU 3.06 Learners are able to differentiate given models with regard to their purpose-specific advantages and disadvantages and to judge which model better represents the considered scenario.	Compare models, Peer feedback			
MU 3.08 Learners are able to check models representing different views of the same scenario for consistency with each other.	Error finding based on two corresponding models		Model building based on another graphical model	
MU 3.09 Learners are able to evaluate a given model in terms of model quality referring to quality criteria.	Check pragmatic quality of a model, Peer feedback	Compare models	Model completing, Model adjusting	

Competence facets	Task type (central / product-related)	Task type (optional)	Task type (marginal / process-related)	Further recommendations
Model building & modifying				
MB 1.01 Learners are able to distinguish between descriptive and prescriptive modeling.	Comprehension task			
MB 1.02 Learners are able to explain different approaches to modeling in terms of level of abstraction and formalization (formal, semi-formal).	Comprehension task			
MB 1.03 Learners are able to explain modeling techniques in different areas of modeling (e.g., model-based requirements engineering, business process modeling).	Comprehension task			
MB 1.04 Learners are able to explain the relevance of the modeling purpose for model building (especially for the selection and use of different modeling techniques).	Comprehension task	Case study		
MB 1.05 Learners are able to explain the effects of certain modifications to a model.	Comprehension task		Model completing, Model adjusting, Case study	
MB 2.01 Learners are able to apply and use modelling tools.	Case study	Model building based on a text describing a scenario, Applying a modeling language, Model building based on (formal) properties or criteria, Model building based on another graphical model, Model completing, Model adjusting		
MB 2.03 Learners are able to apply techniques of modeling structures and/or behaviors.	Applying a modeling language, Model building based on (formal) properties or criteria, Model building based on another graphical model, Model completing, Model adjusting			
MB 2.04 Learners are able to correctly apply syntactical rules of the modeling language/s.	Applying a modeling language, Model building based on (formal) properties or criteria, Model building based on another graphical model, Model completing, Model adjusting, Case study			
MB 2.05 Learners are able to derive identifiers for model elements from a given problem (task and scenario) and use them consistently.	Model completing, Model adjusting			
MB 2.06 Learners are able to use a modeling language in a way that serves a certain purpose or solves a problem at hand.	Model building based on another graphical model		Applying a modeling language	
MB 2.07 Learners are able to select and consistently create/complement corresponding views of a system or scenario with matching models.	Model building based on another graphical model, Model adjusting	Model completing, Case study		
MB 2.08 Learners are able to adapt or further develop a given model due to errors, inconsistencies, incompleteness, or new requirements and add, modify, or remove model elements accordingly.	Model completing, Model adjusting			
MB 2.09 Learners are able to apply conceptual knowledge of modeling using the respective modeling language (e.g., UML, ER, Petri nets, EPC) to build models.	Applying a modeling language, Model building based on another graphical model			
MB 2.10 Learners are able to apply their conceptual knowledge of modeling to use cases of different areas of modeling.		Case study		Design of a diverse task pool: Exercise, exam, and case study tasks should be embedded in different real-world contexts from different areas of graphical modeling.

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MB 2.11 Learners are able to translate general, abstract problems and objectives into concrete specifications and analysis questions.		Model building based on a text describing a scenario, variant II: Development of analysis questions		
MB 2.12 Learners are able to transfer their acquired knowledge and skills to modeling languages and tools that are new to them.				Application of new modeling languages: Students with practical modeling skills should be given the opportunity to independently apply a modeling language that is new to them after a theoretical introduction.
MB 3.01 Learners are able to derive relevant information and requirements (e.g., modeling elements, relationships, etc.) from a problem (task and scenario) and thus structure the problem.			Model building based on a text describing a scenario, Case study	This competence facet is always required in "model building tasks". For novices, it may be useful to provide them with helpful strategies for identifying relevant information and ask them to structure the problem or derive types of model elements before building the model (e.g., "Please identify all classes in the described scenario."). Advanced students should be given more complex tasks that require filtering out relevant information.
MB 3.02 Learners are able to check, evaluate, and select modeling languages or model types for their suitability for a specific application domain and modeling purpose.		Model building based on a text describing a scenario, Case study		Advanced learners with knowledge of different modeling languages should be challenged to select them themselves according to the context.
MB 3.03 Learners are able to select modeling tools based on relevant criteria.				Selection of modeling tools: If possible, learners should be free to select a modeling tool. Different modeling tools should be introduced or recommended.
MB 3.04 Learners are able to reflect on and judge the suitability of a model they have created to represent a specific scenario.	Evaluate model building, Peer feedback		Applying a modeling language, Model building based on (formal) properties or criteria, Model building based on a text describing a scenario, Case study	
MB 3.05 Learners are able to evaluate and justify their design decisions for a model they have created themselves.	Evaluate model building, Peer feedback	Model building based on a text describing a scenario, Case study		
MB 4.01 Learners are able to create graphical models (such as UML diagrams, ER models, and Petri nets) themselves to represent a scenario.	Model building based on a text describing a scenario, Model building based on another graphical model, Case study			
MB 4.02 Learners are able to create a model that is semantically correct and complete with respect to a scenario, and limit themselves to relevant model content (conciseness).	Model building based on a text describing a scenario, Model building based on another graphical model, Case study			
MB 4.03 Learners are able to create understandable and readable models based on known guidelines or conventions.		Case study, Model building based on a text describing a scenario		We recommend that students are made aware of pragmatic quality aspects and that these are included in the grading or feedback. Otherwise, these aspects will be given little consideration, especially in situations with time pressure (e.g. exams).
MB 4.04 Learners are able to develop appropriate and consistent identifiers for model elements.	Model building based on a text describing a scenario, Case study			This is especially the case for more complex tasks.
MB 4.05 Learners are able to select an appropriate level of abstraction in relation to the modeling purpose when creating a model and maintain it consistently within the model.	Model building based on a text describing a scenario, Case study			Depending on the purpose at hand, a model may need to provide an overview, or provide an in-depth analysis. Student should learn to make choices in this regard.
MB 4.06 Learners are able to create a model in a way that is target group-specific, i.e., understandable to a specific group of people.		Case study, Model building based on a text describing a scenario	Model building based on a text describing a scenario	Students could be required to create a model for a certain target group (e.g. non-native speakers, non-IT-persons). Students should learn that visualization of models and pragmatic quality aspects, in particular, affect how models are communicated to stakeholders.

Competence facets	Task type (central / product-related)	Task type (optional)	Task type (marginal / process-related)	Further recommendations
Values, attitudes & beliefs				
VAB 1.01 Learners are able to explain the objectives and relevance of graphical modeling for the respective area of modeling in computer science.	Comprehension task	Case study		Transversal competences could be addressed by comprehension tasks, such as "Please discuss why emphasis should be placed on modeling as part of software design?" or in form of scenario-based questions such as, "Imagine you have to work on a complex modeling task or project. Which aspects should be considered during the task execution and realization as well as in relation to the task solution." However, in order to prevent socially desirable responding, these competence aspects should rather be addressed in application as well as reflected and discussed in the teaching context. Practical tasks are recommended because values, attitudes and beliefs and metacognitive knowledge and skills are embedded in behavior.
VAB 1.02 Learners understand the relevance of high model quality (in terms of syntax, semantics, and pragmatics) for model understandability and subsequent model use.	Comprehension task		Syntactical error finding, Error finding based on a model and a corresponding text, Model building based on another graphical model, Model completing, Model adjusting, Case study, Check pragmatic quality of a model, Check suitability of a model, Compare models, Evaluate model building	Another way of determining or measuring transversal competences for formative purposes is, to conduct self-assessments or assessments by others (e.g., by peers).
VAB 1.03 Learners are convinced that modeling tasks can be solved through adequate procedures and the use of appropriate modeling techniques.	Comprehension task			
VAB 1.04 Learners are convinced that planned action and a systematic procedure are necessary when solving complex modeling tasks.	Comprehension task		Error finding based on a model and a corresponding text, Case study	
VAB 2.01 Learners anticipate and are able to describe the possible consequences of using the models they create (impact assessment).		Case study, Group discussion, Evaluate model building		
VAB 2.02 Learners develop high intrinsic motivation for modeling and interest in its technical innovations and development.			Case study	Teachers could contribute to this by embedding tasks in concrete real-world contexts and scenarios that are interesting and motivating for learners.
VAB 2.03 Learners are willing to take on demanding modeling challenges.			Case study	Learners should be given more complex and challenging tasks in their learning process while receiving individualized support and feedback to avoid overload and to motivate.
VAB 3.01 Learners are able to judge a model from an ethical or social point of view.		Case study, Check suitability of a model, Group discussions		

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Metacognitive Knowledge & Skills				
MC 1.01 Learners understand that methods in the field of graphical modeling (e.g., modeling tools or languages) continue to evolve and therefore recognize the need for lifelong learning.	Comprehension task			Transversal competences could be addressed by comprehension tasks. However, these competence aspects should rather be addressed in application as well as reflected and discussed in the teaching context. Practical tasks are recommended because metacognitive knowledge and skills are embedded in behavior.
MC 2.01 Learners are able to adapt and extend their own skills and knowledge in the field of graphical modeling according to changing situational requirements through independent learning.			Case study	Learners should be required to work on their own on specific topics (e.g., learn a modeling language that is new to them or create a presentation/homework on current topics in the field of modeling).
MC 2.02 Learners are able to control and organize their own learning process and development in the field of graphical modeling.	Reflection task			Educators should encourage self-directed learning (e.g. by providing voluntary formative assessments, learning materials).
MC 2.03 Learners are able to exert themselves and persevere when working on complex modeling tasks.			Case study	Learners should be given more complex and challenging tasks in their learning process while receiving individualized support and feedback to avoid overload and to motivate.
MC 2.04 Learners are able to acquire relevant domain-specific knowledge.		Model building based on a text describing a scenario, Case study, Problem-solving based on a given model	Model building based on a text describing a scenario, Case study	Learners should be confronted with tasks that are embedded in contexts of different application domains. In addition, tasks should be used that require learners to first learn about the domain and to inform themselves (e.g., by means of literature, Internet research, or exchange with domain experts).
MC 3.01 Learners are able to analyze and consciously select problem-solving strategies according to the respective context with regard to their appropriateness and efficiency when working on modeling tasks.			Case study, Reflection task	Adequate problem solving strategies should be discussed in the course.
MC 3.02 Learners reflect on their problem solutions and are able to learn independently from their mistakes.	Reflection task		Case study	Reflection and self-regulation skills are also strengthened through formative assessments and appropriate direct feedback.
MC 3.03 Learners reflect on and evaluate their own level of knowledge and skills related to graphical modeling.	Reflection task			Reflection and self-regulation skills are also strengthened through formative assessments and appropriate direct feedback.
MC 4.01 The learners are willing to take new - previously unknown - approaches when working on complex modeling tasks and thus to distance themselves from the familiar.		Case study		
MC 4.02 Learners are able to find strategic and creative answers when searching for solutions to well-defined, concrete and abstract problems.		Case study		

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Social-communicative skills				
SC 2.01 Learners are able to present models understandable and in a way that is appropriate to the audience (e.g., in relation to the audience's modeling or domain knowledge).		Case study, Interpreting model content (Variant 2, natural language)	Applying a modeling language	
SC 2.02 Learners are able to communicate and share knowledge about relevant modeling and domain knowledge and the content of a model.	Role play, Peer feedback	Interpreting model content (Variant 2, natural language)	Case study	
SC 2.03 Learners are able to make and keep agreements (e.g., regarding task distribution, chosen level of abstraction) in a team when working on complex modeling tasks.		Case study		
SC 2.04 Learners are able to inquire about requirements for the model and the relevant domain knowledge from clients or other stakeholders (possibly also from persons not familiar with computer science) about requirements for the model and the domain knowledge needed, and involve them in the modelling process.		Case study		Since complete scenario descriptions in written form are often not available in professional practice, students should learn to communicate and, if necessary, negotiate with appropriate stakeholders in the course of modeling in order to document the requirements themselves.
SC 2.05 Learners are able to accept and take up ideas from other team members when building models.		Case study		
SC 2.06 Learners are able to put themselves in the role of others (e.g., users, software developers, clients) and change their own perspective.	Role play		Case study	
SC 2.07 Learners are able to check and constructively critique models or model parts of others and accept constructive criticism from others.	Peer feedback	Case study		
SC 2.08 Learners are able to divide complex modeling tasks into subtasks and structure them as well as organize and coordinate the completion of subtasks by different team members or teams.			Case study	When working on group tasks (e.g. case studies), teachers should instruct learners to divide up and distribute tasks (e.g. "Before working on the task, please think about how you can structure the task and divide it into subtasks. Coordinate the subtasks in your team").