Design Pattern for Model-Based Inquiry in Model-Based Reasoning | Design Pattern 2223

Title

Design Pattern for Model-Based Inquiry in Model-Based Reasoning

Overview

This design pattern supports developing tasks in which students work interactively between physical realities and models, using principles, knowledge and strategies that span all aspects and variations of model-based reasoning.

Use

U1. Coordinating the aspects of model-based reasoning in inquiry requires not only being able to reason in each of the specific aspects, but to coordinate their use in iteratively building and testing models as inquiry proceeds. Metacognitive aspects of strategies for model-based reasoning are involved.

Focal knowledge, skills, and abilities

Fk1. Ability to carry out aspects of model-based reasoning when appropriate in an investigation, moving from one to another and using the results of each step to guide the next.

Fk2. Ability to monitor progress and results in inquiry cycle investigations (metacognition, self-regulation)

Fk3. Ability to take appropriate action with regard to model-based inferences in light of real-world feedback

Additional knowledge, skills, and abilities

Ak1. Familiarity with real-world situation

Ak2. Domain area knowledge (declarative, conceptual, and procedural)

Ak3. Familiarity with required modeling tool(s) (e.g., STELLA, Marshall's arithmetic schema interface)

Ak4. Familiarity with required symbolic representations associated procedures (e.g., Marshall's schema forms, mathematical notation)

Ak5. Familiarity with task type (e.g., materials, protocols, expectations)

Ak6. Familiarity with standards of quality & expectation in the field

Ak7. Additional KSAs as might be required in particular aspects of model-based reasoning addressed in design patterns for those aspects

Potential observations

Po1. Presence and quality of activity that reflects self-regulation, including
-Explanation of strategy
-Planning
-Reaction to feedback from other people or the situation itself

Po2. Quality of student's explanation of her own solution through a model (i.e., quality of the student's explanation of their process of model use, as distinct from the quality of the product of their reasoning).

Potential work products

- Pw1. Trace of models as constructed/revised during investigation
- Pw2. Explanations of steps taken during an investigation, moving across inquiry steps.
- Pw3. Audio-recordings or transcripts of what students said as they "thought aloud" while solving problems
- Pw4. Computer-kept or notebook records of inquiry steps
- Pw5. Filling out forms summarizing work by step or category. details
- Pw6. Work products as might be required in particular aspects of model-based reasoning addressed in design patterns for those aspects
- Pw7. Final and intermediate products of solution can hold indirect evidence about inquiry capabilities. Final products that illustrate appropriate models and conclusions suggest appropriate model formation and use at a minimum. Increasingly improved intermediate products suggest appropriate model evaluation and model revision or elaboration.

Potential rubrics

Characteristic features

- Cf1. Necessity to probe a problem by invoking or revising models to explain phenomena or make predictions. One or more inquiry cycles, and more than one aspect of inquiry, is required, so that managing interaction among them is required.

Variable features

- Vf1. Amount of scaffolding provided for working through inquiry cycles (from being walked through cycles, to support within cycles, to unsupported) Note: Scaffolding can be in the form of structured work products.
- Vf2. Single cycle or multiple cycles anticipated?
- Vf3. Problem given or self-determined in accordance with some criteria?
- Vf4. Is problem context familiar?
- Vf5. Time scale (e.g., relatively short snippets of fuller investigations as might appear in a large-scale test; short hands-on or simulation tasks, say 30-90 minutes; investigations that are carried out over days or weeks)
- Vf6. Opportunities to engage in persuasion of peers in defense of their own solutions?
- Vf7. Group or individual work?
- Vf8. Variable features as might be required in particular aspects of model-based reasoning addressed in design patterns for those aspects

Narrative structure

Cause and effect. An event, phenomenon, or system is altered by internal or external factors.

Change over time. A sequence of events is presented to highlight sequential or cyclical change in a system.

General to Specific or Whole to Parts. A general topic is initially presented followed by the presentation of specific aspects of the general topic.

Investigation. A student or scientist completes an investigation in which one or more variables may be observed or manipulated and data are collected

Specific to general and Parts to whole. Specific characteristics of a phenomenon are presented, culminating in a description of the system or phenomenon as a whole.

Topic with Examples. A given topic is presented using various examples to highlight the topic.

National educational standards

State standards

State benchmarks

MCA III: 6.1.3.4.1. Determine and use appropriate safe procedures, tools, measurements, graphs and mathematical analyses to describe and investigate natural and designed systems in a physical science context.

MCA III: 7.1.1.1.1. Understand that prior expectations can create bias when conducting scientific investigations. For example: Students often continue to think that air is not matter, even though they have contrary evidence from investigations.

MCA III: 7.1.1.2.1. Generate and refine a variety of scientific questions and match them with appropriate methods of investigation, such as field studies, controlled experiments, reviews of existing work and development of models.

MCA III: 7.1.1.2.2. Plan and conduct a controlled experiment to test a hypothesis about a relationship between two variables, ensuring that one variable is systematically manipulated, the other is measured and recorded, and any other variables are kept the same (controlled). For example: The effect of various factors on the production of carbon dioxide by plants.

MCA III: 7.1.1.2.3. Generate a scientific conclusion from an investigation, clearly distinguishing between results (evidence) and conclusions (explanation).

MCA III: 7.1.3.4.1. Use maps, satellite images and other data sets to describe patterns and make predictions about natural systems in a life science context. For example: Use online data sets to compare wildlife populations or water quality in regions of Minnesota.

MCA III: 7.1.3.4.2. Determine and use appropriate safety procedures, tools, measurements, graphs and mathematical analyses to describe and investigate natural and designed systems in a life science context.

MCA III: 8.1.1.2.1. Use logical reasoning and imagination to develop descriptions, explanations, predictions and models based on evidence.

MCA III: 8.1.3.4.1. Use maps, satellite images and other data sets to describe patterns and make predictions about local and global systems in Earth science contexts. For example: Use data or satellite images to identify locations of earthquakes and volcanoes, ages of sea floor, ocean surface temperatures and ozone concentration in the stratosphere.

MCA III: 8.1.3.4.2. Determine and use appropriate safety procedures, tools, measurements, graphs and mathematical analyses to describe and investigate natural and designed systems in Earth and physical science contexts

contexts.

I am a kind of

These are kinds of me

These are parts of me

Design Pattern for Model Articulation in Model-Based Reasoning. Tasks supported by this design pattern assess student's ability to articulate the meaning of physical or abstract systems across multiple representations. Representations may take qualitative or quantitative forms. This DP is relevant in models with quantitative and symbolic components (e.g., connections between conceptual and mathematical aspects of physics models) Model articulation is often be pertinent in multiple-step tasks, after the model formation step.

Design Pattern for Model Elaboration in Model-Based Reasoning. This design pattern supports developing tasks in which students elaborate given scientific models by combining, extending, adding detail to a model, and/or establishing correspondences across overlapping models. This design pattern can considered a special case of model formation in that the aim is to develop a modeled conception of a situation. But the emphasis is what is happening in the model layer with respect to extensions of models or connections between models. Model elaboration is also similar to model revision, in that a given model or a set of unconnected models does not account properly for the target situation and reformulation is required.

Design Pattern for Model Evaluation in Model-Based Reasoning. This design pattern supports developing tasks in which students evaluate the correspondence between a model and its real-world counterparts, with emphasis on anomalies and important features not accounted for in the model. This design pattern is tied closely with model use, and is also associated with model revision and model elaboration.

Design Pattern for Model Formation in Model-Based Reasoning. This design pattern supports developing tasks in which students create a model of some real-world phenomenon or abstracted structure, in terms of entities, structures, relationships, processes, and behaviors. The Model Formation design pattern can be viewed as a subpart of the Model-Based Inquiry design pattern, and many tasks combine Model Formation with Model Use. The Model Formation design pattern also overlaps with those for Model Elaboration and Model Revision.

Design Pattern for Model Revision in Model-Based Reasoning. This design pattern supports developing tasks in which students revise a model in situations where a given model does not adequately fit the situation or is not sufficient to solve the problems at hand. Because of its very centrality, model revision is difficult to assess in isolation from other aspects of model-based reasoning. Model revision is prompted only by model evaluation, and then model formation must be used to propose alternatives or modifications.

Design Pattern for Model Use in Model-Based Reasoning. This design pattern supports developing tasks that require students to reason through the structures, relationships, and processes of a given model. Model use is often combined with model formation in the same tasks, and most tasks that address model evaluation and model revision also involve model use.

Templates

Exemplar tasks

Online resources

References

R1. Mosteller & Tukey (1977)

R2. Stewart, Hafner, Johnson, & Finkel (1992).

R3. White & Frederiksen (1998)

Tags [Add Tag]

(No tags entered.)

List of Examples:

Activity Add'l KSAs: Affective Add'l KSAs: Cognitive Add'l KSAs: Executive Add'l KSAs: Language and Symbols Add'l KSAs: Perceptual Add'l KSAs: Skill and Fluency Continuous Zone Design Pattern Educational Standard Evaluation Phase Evaluation Procedure (rubric) Materials and Presentation Measurement Model Narrative Structure Observable Variable State Benchmark State Standards Student Model Student Model Variable Task Exemplar Task Model Variable Task Specification Template Variable Features: Affective Variable Features: Cognitive Variable Features: Executive Variable Features: Language and Symbols Variable Features: Perceptual Variable Features: Skill and Fluency Work Product

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