Design Pattern for Observational Investigation | Design Pattern 2167

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Title

Design Pattern for Observational Investigation

Overview

This design pattern supports the writing of tasks that address scientific reasoning and process skills in observational (non-experimental) investigations. Observational investigations differ from experimental investigations. In experimental investigations, it is necessary to control or manipulate one or more of the variables of interest to test a prediction or hypothesis; in observational investigations, variables typically cannot be altered at all (e.g., objects in space) or in a short time frame (e.g., a lake ecosystem). This design pattern may be used to generate groups of tasks for any science content strand.

Use

U1. This design pattern supports the construction of tasks that address observational investigations - that is, investigations where experimental methods are not appropriate (e.g., earth and space science, demography, paleoanthropology, physiology, ecology). In order for students to have a well-rounded understanding of the scientific method, they need to be familiar with the context and methods of observational investigations. details

Focal knowledge, skills, and abilities

Fk1. Ability to analyze why observational investigation methods are more appropriate than experimental methods for some phenomena/situations details

Fk2. Ability to distinguish between observational and experimental methodology details

Fk3. Ability to generate or evaluate predictions or hypotheses about scientific phenomena that are appropriate for observational investigation details

Fk4. Ability to formulate conclusions, create models, and appropriately generalize results from observational investigations details

Fk5. Ability to test predictions or hypotheses using observational methods details

Fk6. Ability to plan a systematic collection of observational data based on a predicted relationship

Fk7. Ability to collect, analyze, and interpret observational data with appropriate tools

Additional knowledge, skills, and abilities

Ak1. Content knowledge (may be construct relevant) details

Ak2. Prerequisite knowledge from earlier grades details

Ak3. Data collection and analysis details

Ak4. Representational forms (e.g., graphs, maps) details

Potential observations

- Po1. Appropriateness/strength of observational evidence to help confirm or disconfirm a prediction or hypothesis details
- Po2. Accuracy in identifying the effects of an observed active phenomenon and how these effects are consistent with a posited cause and effect relationship details
- Po3. Correctness of recognized pattern in data to support a prediction or hypothesis details
- Po4. Plausibility/correctness of explanation for observed findings details
- Po5. Accuracy in critiquing the observational investigation methods, evidence, and conclusions of others details
- Po6. Plausibility and systematicity of the data collection plan
- Po7. Correctness of selected tools and procedures for data collection
- Po8. Systematicity and appropriateness of collected data
- Po9. Appropriateness of measurement precision

Potential work products

- Pw1. Identification or generation of a prediction or hypothesis that is appropriate to an observational investigation situation details
- Pw2. Identification of observational settings where data could be collected to confirm or disconfirm a prediction or hypothesis details
- Pw3. Identification of additional source of data that could confirm or disconfirm a prediction or hypothesis supported by existing data details
- Pw4. Identification or generation of a replicable data collection process (e.g., repeated sampling over time or at several locations) details
- Pw5. Identification of potentially disconfirming observations
- Pw6. Filling in of a representational form (e.g., a graph, chart, or map) to show the relationship among variables relevant to a prediction or hypothesis details
- Pw7. Generation or selection of an explanation for observed findings details
- Pw8. Critique of flawed explanation based on observations
- Pw9. Peer critique (hypothetical in a standard assessment, real in classroom work) of the observational investigation methods, evidence, and conclusions details

Potential rubrics

Characteristic features

- Cf1. Scientific question not amenable to experimentation, because impractical, unethical, etc. details
- Cf2. Presentation of a real-world situation with patterns suggesting the relationship between at least two variables that can be observed systematically (but are not amenable to experimental investigation). details

Variable features

- Vf1. Content (strand) context details

Vf2. Qualitative or quantitative investigations details

Vf3. Number of variables and the complexity of their relationships details

Vf4. Simple or complex investigations details

Vf5. Type of data representation (e.g., patterns in geographically distributed phenomena via geospatial visualizations; patterns in data; similarities in specialized representations appropriate to the scientific phenomenon) details

Vf6. Sufficient or insufficient data about an already established relationship details

Vf7. Amount of scaffolding given to student to guide the presentation or representation of data collected details

Vf8. Amount of observational data from which an analysis, explanation, or conclusion is to be drawn details

Vf9. Completeness of model given from which predictions or hypotheses can be generated details

Vf10.

Vf11.

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.

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.

National educational standards

NSES 8ASI1.1. Identify questions that can be answered through scientific investigations. Students should develop the ability to refine and refocus broad and ill-defined questions. An important aspect of this ability consists of students' ability to clarify questions and inquiries and direct them toward objects and phenomena that can be described, explained, or predicted by scientific investigations. Students should develop the ability to identify their questions with scientific ideas, concepts, and quantitative relationships that guide investigation.

NSES 8ASI1.2. Design and conduct a scientific investigation. Students should develop general abilities, such as systematic observation, making accurate measurements, and identifying and controlling variables. They should also develop the ability to clarify their ideas that are influencing and guiding the inquiry, and to understand how those ideas compare with current scientific knowledge. Students can learn to formulate questions, design investigations, execute investigations, interpret data, use evidence to generate explanations, propose alternative explanations, and critique explanations and procedures.

NSES 8ASI1.3. Use appropriate tools and techniques to gather, analyze, and interpret data. The use of tools and techniques, including mathematics, will be guided by the question asked and the investigations students design. The use of computers for the collection, summary, and display of evidence is part of this standard.

Students should be able to access, gather, store, retrieve, and organize data, using hardware and software designed for these purposes.

NSES 8ASI1.4. Develop descriptions, explanations, predictions, and models using evidence. Students should base their explanation on what they observed, and as they develop cognitive skills, they should be able to differentiate explanation from description, providing causes for effects and establishing relationships based on evidence and logical argument. This standards requires a subject knowledge base so the students can effectively conduct investigations, because developing explanations establishes connections between the content of science and the contexts within which students develop new knowledge.

NSES 8ASI1.5. Think critically and logically to make the relationships between evidence and explanations. Thinking critically about evidence includes deciding what evidence should be used and accounting for anomalous data. Specifically, students should be able to review data from a simple experiment, summarize the data, and form a logical argument about the cause-and-effect relationships in the experiment. Students should begin to state some explanations in terms of the relationship between two or more variables.

NSES 8ASI1.6. Recognize and analyze alternative explanations and predictions. Students should develop the ability to listen and to respect the explanations proposed by other students. They should remain open to and acknowledge different ideas and explanations, be able to accept the skepticism of others, and consider alternative explanations.

State standards

State benchmarks

MCA II: 6.I.A.2. The student will explain why scientists often repeat investigations to be sure of the results.

MCA II: 7.I.A.2. The student will explain natural phenomena by using appropriate physical, conceptual and mathematical models.

MCA II: 6.I.B.1. The student will identify questions that can be answered through scientific investigation and those that cannot.

MCA II: 7.I.B.1. The student will formulate a testable hypothesis based on prior knowledge.

MCA II: 6.I.B.2. The student will distinguish among observation, prediction and inference.

MCA II: 6.I.B.4. The student will present and explain data and findings from controlled experiments using multiple representations including tables, graphs, physical models and demonstrations.

MCA II: 8.I.B.1. The student will know that scientific investigations involve the common elements of systematic observations, the careful collection of relevant evidence, logical reasoning and innovation in developing hypotheses and explanations.

MCA II: 8.I.B.2. The student will describe how scientists can conduct investigations in a simple system and make generalizations to more complex systems.

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: 7.1.1.1.2. Understand that when similar investigations give different results, the challenge is to judge whether the differences are significant, and if further studies are required. For example: Use mean and range to analyze the reliability of experimental results.

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MCA III: 8.1.1.1.1. Evaluate the reasoning in arguments in which fact and opinion are intermingled or when conclusions do not follow logically from the evidence given. For example: Evaluate the use of pH in advertising products related to body care and gardening.

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

MCA III: 7.1.1.2.4. Evaluate explanations proposed by others by examining and comparing evidence, identifying faulty reasoning, and suggesting alternative explanations.

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

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: 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.

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Templates

Exemplar tasks

Online resources

References

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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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