



Components of Instruction

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Components of Instruction



"The cutting edge of science is reductionism, the breaking apart of nature into its natural components." Wilson, 1998

Engineering (Design) Science

"In scientific knowledge the purpose is understanding of nature; in engineering science the ultimate goal is the creation of artifacts."

Vincenti, 1990

Engineering science is putting together fundamental scientific laws with design procedures in an organized and purposeful way. Its purpose is the development of theoretical tools for design.

Why Theoretical Design Tools?

- **Teaching** -- a search for improved ways to organize the resulting knowledge.
- **Economy** -- a search for design processes that are possible with limited resources of time, money and manpower.
- **Accuracy** -- a search for ways to avoid mistakes resulting from human error, lack of imagination, or blind ignorance.

Vincenti, 1990

Stages in the development of Theoretical Design Tools

1. Ad hoc solutions
- ➔ 2. Theoretical tools for analysis and synthesis
3. Generalization of theoretical tools
4. Diffusion of theoretical tools

Fundamental Design Concepts

"Designers bring with them fundamental concepts about the device in question."

"Designers must first know ... the **operational principle**... how the device works."

"A second thing the designer takes for granted is the **normal configuration** ... the general shape and arrangement that are commonly agreed to best embody the operational principle."

Vincenti 1990

Some operational principles and normal configurations for instruction

- Information -- lecture
- Tutorial -- presentation, practice, feedback
- Experiential -- guided discovery
- Exploratory -- discovery - collaboration

Clark 1998

A theoretical design tool

Instructional components are a theoretical tool for designing effective, efficient, and appealing tutorial and experiential instructional products and environments.

Instructional Design

Two major activities:

- Determine what to teach?
Knowledge Analysis
- Determine how to teach?
Strategy Analysis

Instructional Prescriptions

IF Knowledge/Skill then Instructional Strategy

Descriptive
Theory
of
Knowledge

Descriptive
Theory
of
Strategy

Science and design cannot proceed until we have first selected the components of nature to which we will attend.

Knowledge Analysis via Knowledge Objects?

- A knowledge object is a precise way to describe the content to be taught.
- A knowledge object is a set of containers for information:
 - that name, describe or illustrate some entity
 - that name, describe or illustrate parts of an entity
 - that identify properties of an entity or part
 - that identify actions associated with the entity
 - that identify processes that modify the entity
- The knowledge object framework is the same
 - for a wide variety of different topics within a subject matter domain,
 - or for knowledge in different subject matter domains.

Learning Objects vs Knowledge Objects

Learning objects are not the same as knowledge objects.

- Learning Objects are small modules of instruction.
- Knowledge objects are **not** complete modules of instruction.
- Learning objects are usually defined as an objective, some instructional information, and assessment.
- Knowledge objects include **only the content** to be learned but not an objective, presentation, or assessment.

Learning Objects vs Knowledge Objects

- Learning Objects combine the knowledge to be learned with the strategy for presenting, practicing, or assessing this knowledge.
- Knowledge objects are uncoupled from the instructional or information strategies used to present them.
- Learning objects have a given instructional strategy built-in.
- A given knowledge object can be used for a variety of different instructional strategies.
 - Knowledge objects can be used in visualizations and experiential environments.
 - Knowledge objects can be used for practice or assessment.
 - Knowledge objects can be used for simulation, visualization, or experiential environments.

Components of a knowledge object

Information:

Name
Description
Portrayal

Part:

Name
Description
Portrayal

Property:

Name
Description
Value
Value Portrayal

Kind:

Name
Description
Definition (list of property values)

Activity:

Name
Description
Portrayal
Process trigger
Steps

Process:

Name
Description
Condition (value of Property)
Consequence (property value changed)
Process trigger
Events

Knowledge object for sentence

Name: sentence

Description: a group of words that expresses a complete thought.

Part: subject

Description: tells whom or what the sentence is about

Part: predicate

Description: tells something about the subject.

Property: purpose

Values: makes statement, asks question, gives command, expresses emotion

Property: punctuation

Values: period, question mark, exclamation point

Knowledge Base

- A knowledge base is the set of examples or illustrations of the content to be taught.
- A knowledge base provides a specific representation (portrayal) or value for each of the components of the knowledge object.
- A knowledge base includes a number of different content objects each of which provides a specific representation or value for each of the components of the knowledge object.

Knowledge base for sentence

Portrayal:	Sentence Information	The sentence is a group of words that expresses a complete thought. It begins with a capital letter and ends with a period, a question mark, or an exclamation point.
Part:	Subject Information	The subject of a sentence is the words needed to tell whom or what the sentence is about. The subject does not always come at the beginning of the sentence.
Part:	Predicate Information	The predicate of a sentence is the words that are not part of the complete subject. It is all the words that are not part of the complete subject.
Property:	Purpose	expression
Property:	Punctuation	period, question mark, exclamation point

Instructional Strategy Components

The primary strategy components are:

TELL - ASK
SHOW - DO

The fundamental architecture of an instructional strategy is a combination of primary strategy components and knowledge components appropriate for, and consistent with, a given instructional goal.

Kinds Presentation: for sentences

Tell definition of kind
Show portrayal of matched examples

Click on a kind of sentence to see an example.

Declarative **Interrogative** **Imperative** **Exclamatory**

The portrayal provides an example. The explanation is generated from the property values using a text template: "This sentence <purpose property value> and ends with a <punctuation property value>." The algorithm selects the first example which shares the property values that define the kind.

Kinds Practice: for sentences

Do identify portrayal as to kind
Do indicate portrayal of defining properties

What kind of sentence is the following? Click to begin.

The smell of a wood fire makes me think of camping.

Declarative **Imperative** **Interrogative** **Exclamatory**

Correct.

Reason is highlighted.

Why? Click on the reason.

Tells a fact about the subject. Is said with feeling.
 Asks the subject to do something. Makes an inquiry.

Kinds Practice: for sentences

Do identify portrayal as to kind
Do indicate portrayal of defining properties

What kind of sentence is the following? Click to begin.

What a terrific show we saw!

Declarative **Imperative** **Interrogative** **Exclamatory**

Correct.

Reason is highlighted.

Why? Click on the reason.

Tells a fact about the subject. Is said with feeling.
 Asks the subject to do something. Makes an inquiry.

Try Again.

Using knowledge objects to teach activities and processes

Properties not only allow us to define kinds but when combined with a simulation engine enable us to demonstrate and allow the student to practice procedures (activities) and processes.

The next few slides will demonstrate the use of knowledge objects to build visualizations that the student can manipulate.

Components for How-to

TELL	SHOW	ASK	DO
action name	action portrayal	action name	Action
action description*	process consequence portrayal	action description*	
process trigger		order of actions	
process condition			
process consequence			

* Often included but not required for a how-to-lesson.

Components for What-happens

TELL	SHOW	ASK	DO
process name	process portrayal	process name	predict consequence
process description*	process consequence portrayal	process description*	find faulted conditions
process conditions			
process consequence			

* Often included but not required for a what-happens lesson.

Knowledge Object

- NAME
 - Switch
- DESCRIPTION
 - Turns light on or off
- PORTRAYAL
 - see picture at right



Properties of Knowledge Object

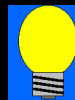
- Property name: switch position
- Legal values of property: down, up
- Indicator (portrayal of legal values):



- Current value:

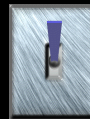
Components of Knowledge Object

- Entity -- an object
 - switch, lamp
- Activity -- an action of the learner
 - flip switch
- Process -- what happens
 - light lamp

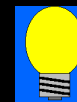


Elements of an Activity

- Action
 - an action taken by the student
- Trigger
 - a message to a process to execute



Flip Switch



Turn on light.

Elements of a Process

- Consequence
 - changes the values of one or more properties
- Feedback
 - displays or plays media object
- Conditions
 - one or more property values
- Process trigger
 - sends message to one or more processes to execute



property: lighted = on

Knowledge Object PEAnet



entity: switch

indicator up

activity: flip switch

triggers

process: toggle switch

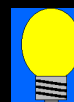
changes property switch position to up

triggers

process: light lamp

condition: property burned out = false

changes property lamp lighted to on



entity: lamp

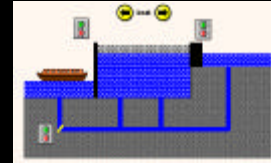
indicator on

Demonstration



Simplifying Instructional Simulation.

Components of a property



- Name -- lock position of canal boat
- Legal values -- below, in, above
- Current value -- below
- Indicator (portrayal)
 - position on animation grove

Components of an action

- An action is a trigger for a process
 - Push lower gate opener (controller) part of the entity canal lock
 - Trigger -- process open of lower gate

yellow = action
green = entities
red = process

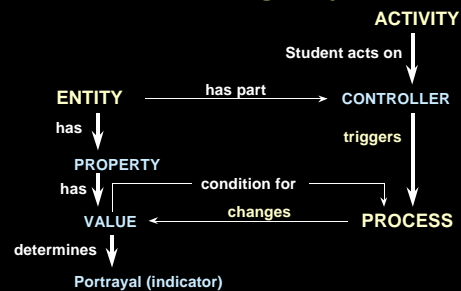
Components of a process

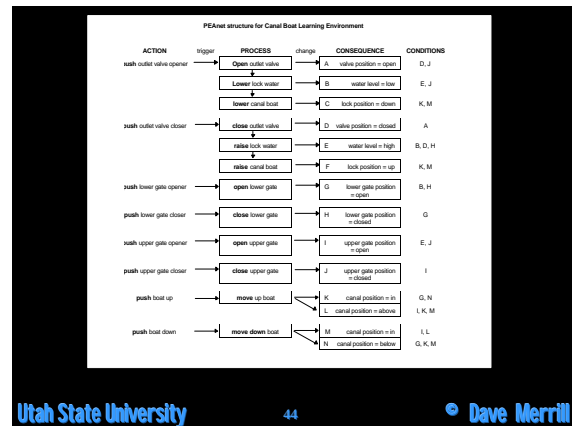
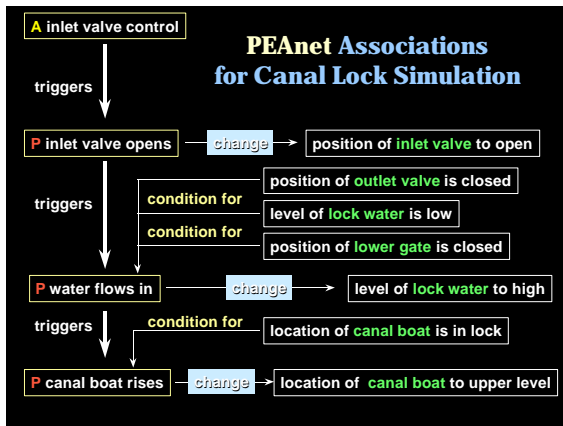
- Consequence (can have more than one)
 - a change in the value of the property of an entity
- Condition (can have more than one)
 - a value on the property of an entity
- Feedback (can have more than one)
 - any media, combination of media or an external program displayed when a process executes
- Trigger (can have more than one)
 - a message to another process to execute

Canal lock entities

Entity	Property	Legal values
outlet valve	position	open, closed
upper gate	position	open, closed
lower gate	position	open, closed
lock water	level	high, low
canal boat	canal position lock position	below, in, above up, down

PEAnet Associations for Knowledge Objects





Summary

- A knowledge object identifies necessary and appropriate components of content.
- Components of knowledge objects include:
 - parts of an entity
 - properties of an entity or part
 - kinds of an entity or part
 - activities associated with the entity
 - processes associated with the entity
- A knowledge base provides a specific representation (portrayal) or value for each of the components of the knowledge object.

Summary

Summary A theoretical design tool

Instructional components are a theoretical tool for designing effective, efficient, and appealing tutorial and experiential instructional products and environments.

“The great success of the natural sciences has been achieved substantially by the reduction of each phenomenon to its constituent elements, followed by the use of the elements to reconstitute the holistic properties of the phenomenon.”

Wilson, 1998

More about Instructional Components

See the following papers:

Merrill, M. David & ID₂ Research Group (1996). Instructional Transaction Theory: Instructional Design based on Knowledge Objects. *Educational Technology*, 36(3), 30-37.

Merrill, M. David. Knowledge Objects. *CBT Solutions*, March/April 1998, 1-11.

Merrill, M. David (1999). Instructional Transaction Theory (ITT): Instructional Design based on Knowledge Objects. In Charles M. Reigeluth (Ed.), *Instructional Design Theories and Models*, Volume 2. LEA Publishers.

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ID₂ development tools

 Accelerator

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