Inside Theory-Aware Authoring System

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Osaka University
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Tele University

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Structure of this talk

- Introduction
- Part 1: How SMARTIES works
  - Functionality and computational aspect of ontology use
    Presented by Yusuke Hayashi
- Part 2: How the ontology is built and its underlying philosophy of its design
  - Ontology engineering aspect
    Presented by myself

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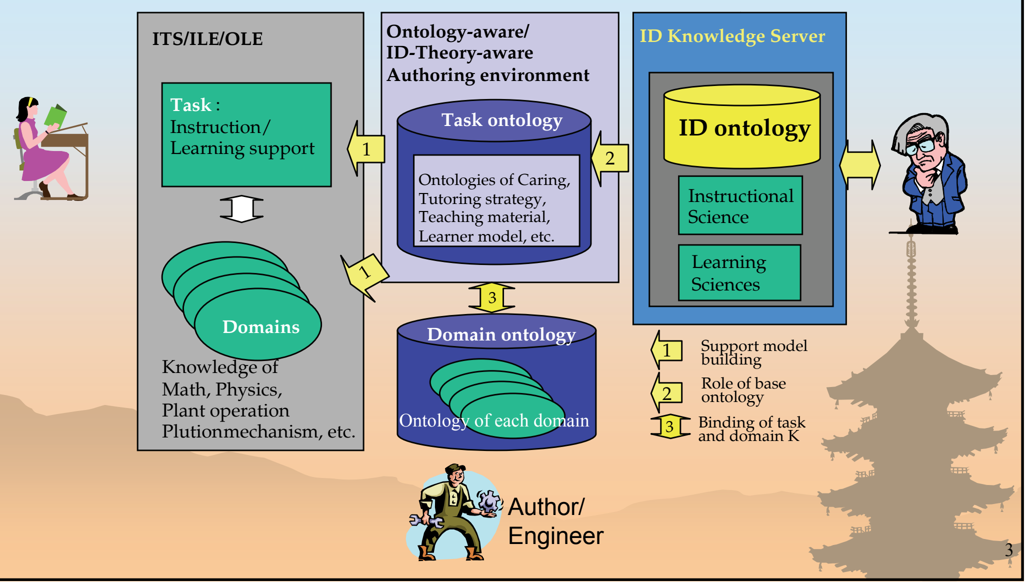
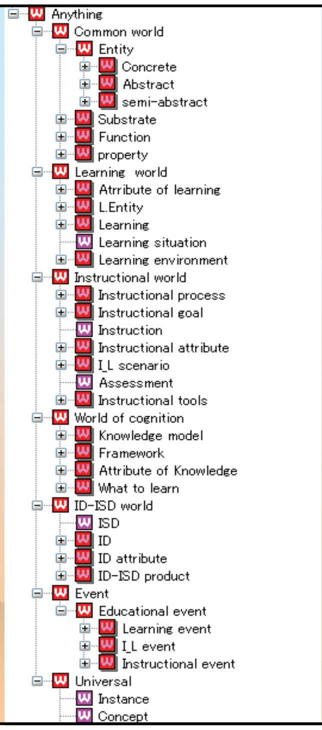
Our dream at the time of 2000

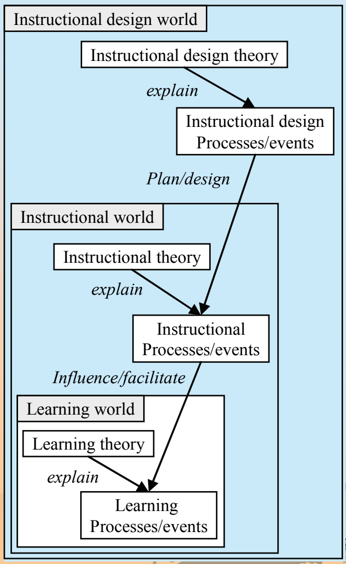


Main objectives of OMNIBUS project

- Realization of
  - **Theory-awareness** and **Standards-compliance**
  - Fluent flow of knowledge from theoreticians to practitioners (authors, learners, etc.)
    - so that they enjoy intelligent guidance by the system to produce ***theory-*** and ***standards-compliant*** scenarios
  - **To prevent blind configuration of LOs** under the slogan: repurposing/reuse of LOs using standards
  - Eventually, to enable to **capture Best Practices** as empirical theories

Concepts: 980
Relations: 156
Slots: 3952





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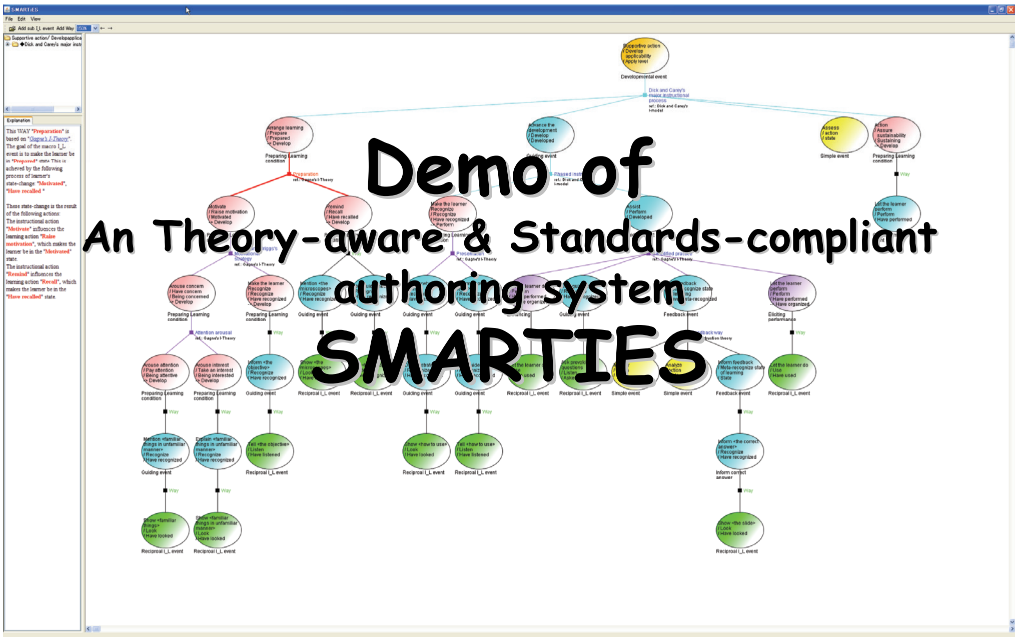
Demo of
An Theory-aware & Standards-compliant authoring system
SMARTIES



Overview of SMARTIES

- **The objective**
  - Theory-based design support for standards-compliant learning contents
- **What SMARTIES can do:**
  - **Modeling framework** for scenario design
  - **Concepts and vocabulary** for scenario design
  - **Multiple theory-based guidelines** for scenario design
    - **Application** of a theory to a scenario
    - **Blending multiple theories** into a scenario
    - **Finding similar theories** to an author's own strategy
  - Preservation of **design rationale** of a scenario with **Theoretical justification** of a scenario
  - **Explanations** of scenarios and theories
  - **Consistency check** of scenario-flow
  - Scenario-**export** with design rationale
    - simple scenario description
    - IMS LD-compliant format

Coverage of SMARTIES

- **Covered:**
  - Abstract design phase of learning/instructional design
    - Skeleton of a scenario
    - Structure of design rationale (justified by theories)
- **Not covered yet:**
  - Detailed design of learning/instructional scenario
    - Learning objects design & its use
  - Execution of scenarios
    - Adaptation to learners' actual states

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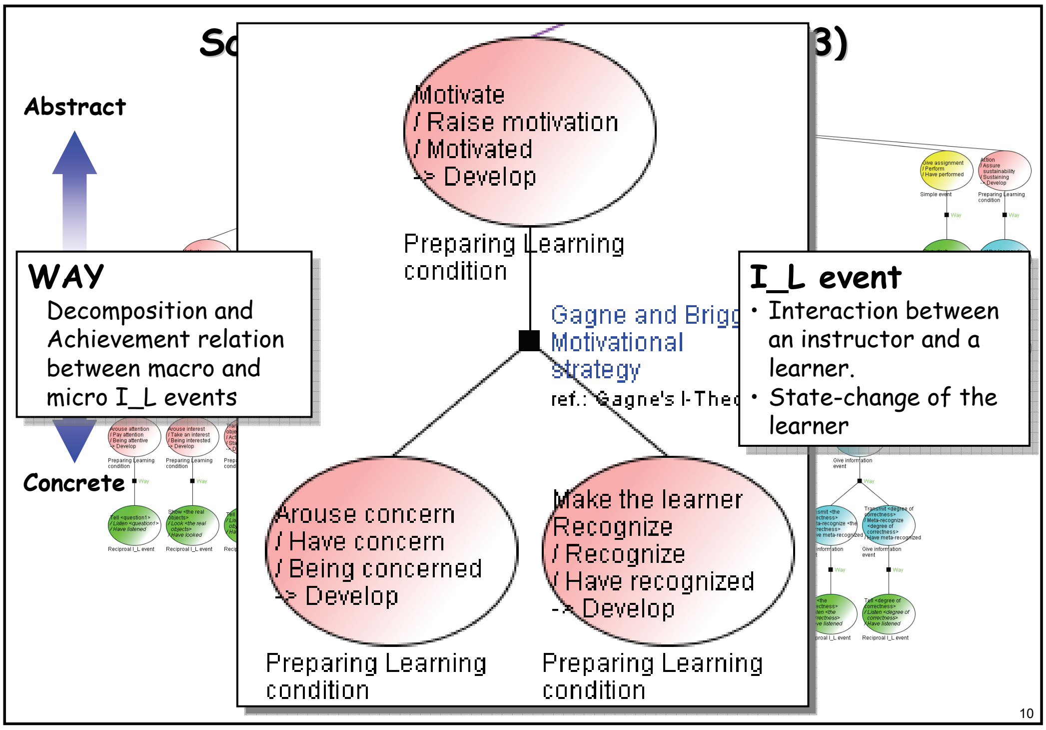

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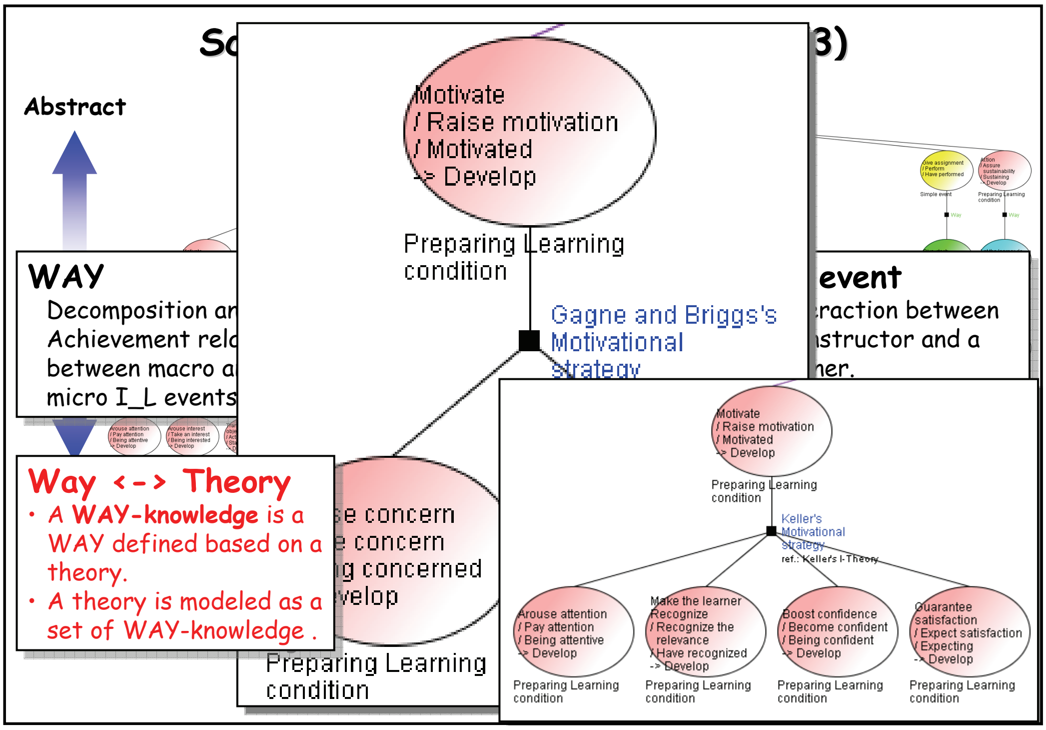
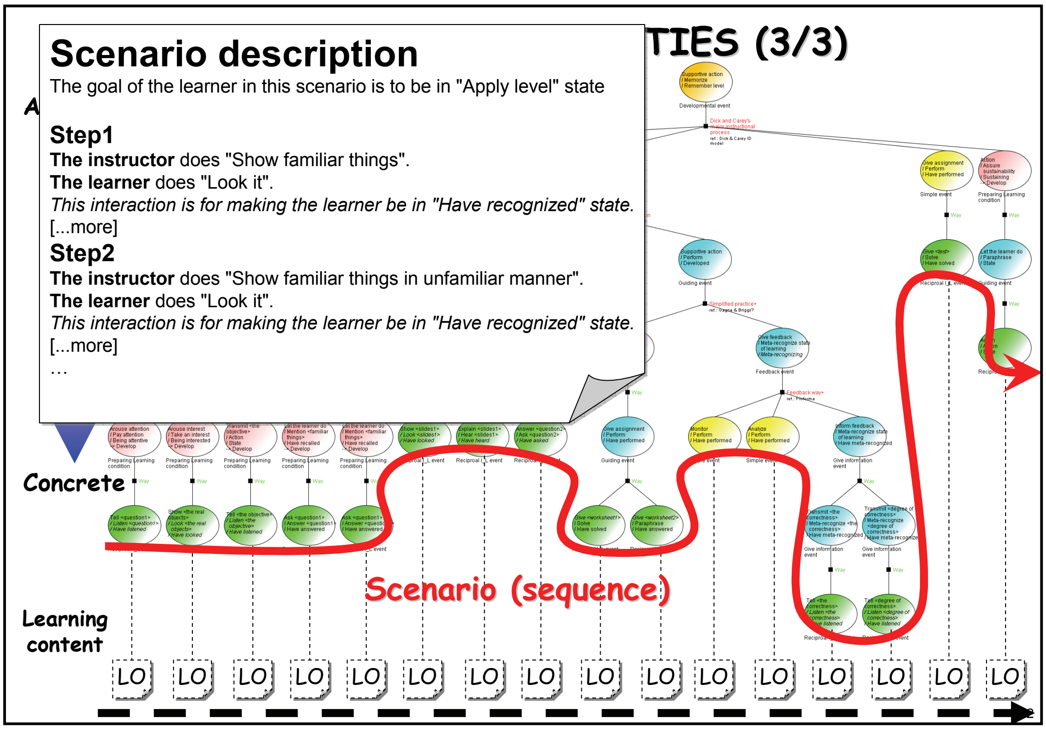
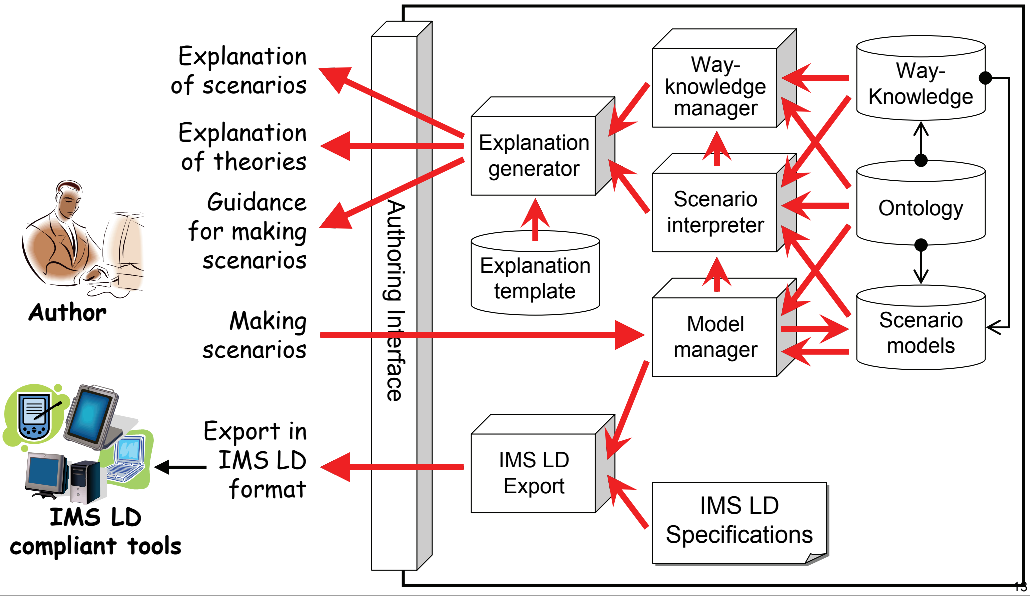

Abstract
WAY
Decomposition an
Achievement rela
between macro a
micro I_L events
Motivate
/ Raise motivation
/ Motivated
-> Develop
Preparing Learning
condition
Gagne and Briggs's
Motivational
strategy
e concern
e concern
g concerned
velop
Preparing Learning
condition
event
raction between
nstructor and a
ner.
Way <-> Theory
• A WAY-knowledge is a WAY defined based on a theory.
• A theory is modeled as a set of WAY-knowledge .
Motivate
/ Raise motivation
/ Motivated
-> Develop
Preparing Learning
condition
Keller's
Motivational
strategy
ref.: Keller's I-Theory
Arouse attention
/ Pay attention
/ Being attentive
-> Develop
Preparing Learning
condition
Make the learner
Recognize
/ Recognize the
relevance
/ Have recognized
-> Develop
Preparing Learning
condition
Boost confidence
/ Become confident
/ Being confident
-> Develop
Preparing Learning
condition
Guarantee
satisfaction
/ Expect satisfaction
/ Expecting
-> Develop
Preparing Learning
condition


TIES (3/3)
Scenario description
The goal of the learner in this scenario is to be in "Apply level" state
Step1
The instructor does "Show familiar things".
The learner does "Look it".
This interaction is for making the learner be in "Have recognized" state.
[...more]
Step2
The instructor does "Show familiar things in unfamiliar manner".
The learner does "Look it".
This interaction is for making the learner be in "Have recognized" state.
[...more]
…
Concrete
Scenario (sequence)
Learning
content
LO

A system architecture of a theory-aware authoring tool



Demonstration of SMARTIES

1. **Scenario making**
   - **Multiple theory-based guidelines** for scenario design
     - **Application** of a theory to a scenario
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   - Scenario-**export** with design rationale
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Demonstration of SMARTIES (1/3)

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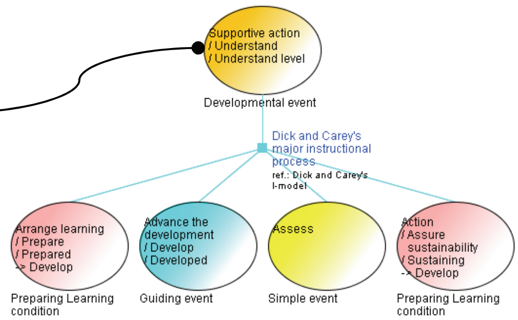
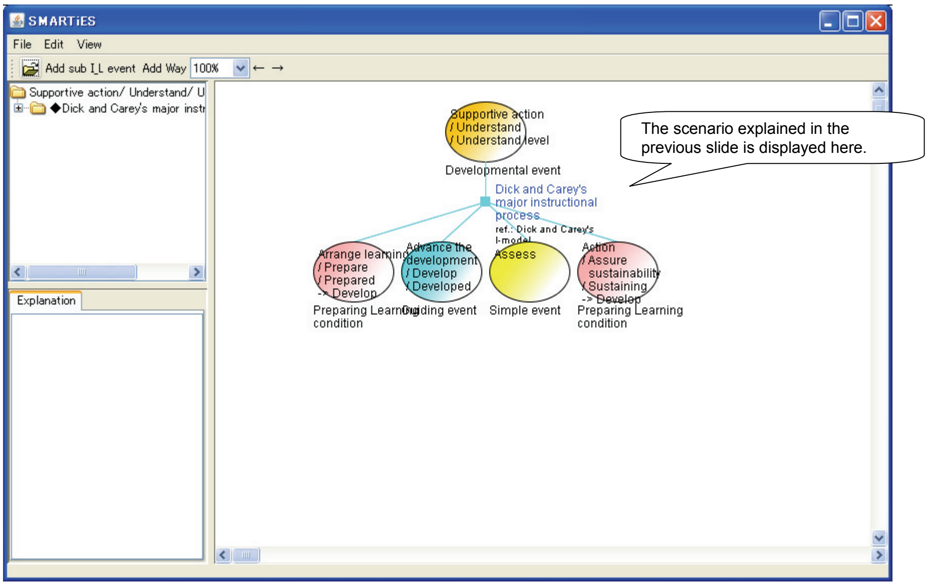
Scenario setting

- **Situation**
  - Learner: School kids, learning in the classroom
  - Object: A concept
  - Goal: Understanding of the target concept
    - Already knowing the concept
    - After this scenario the learner learn to apply it.
- **Setting of the root I_L event**

Slots	Value
Type of I_L event	Developmental event
Learner property: Age (type)	School kid
Learner property: Context	Classroom learning
Object property: Content type	Concept
Instructional action	Supportive action
Learning action	Understand
State of learner	Understand level

- **Main flow of learning/instruction**
  - Preparation -> Development -> Assessment -> Follow-up





The main window of SMARTIES (1/2)

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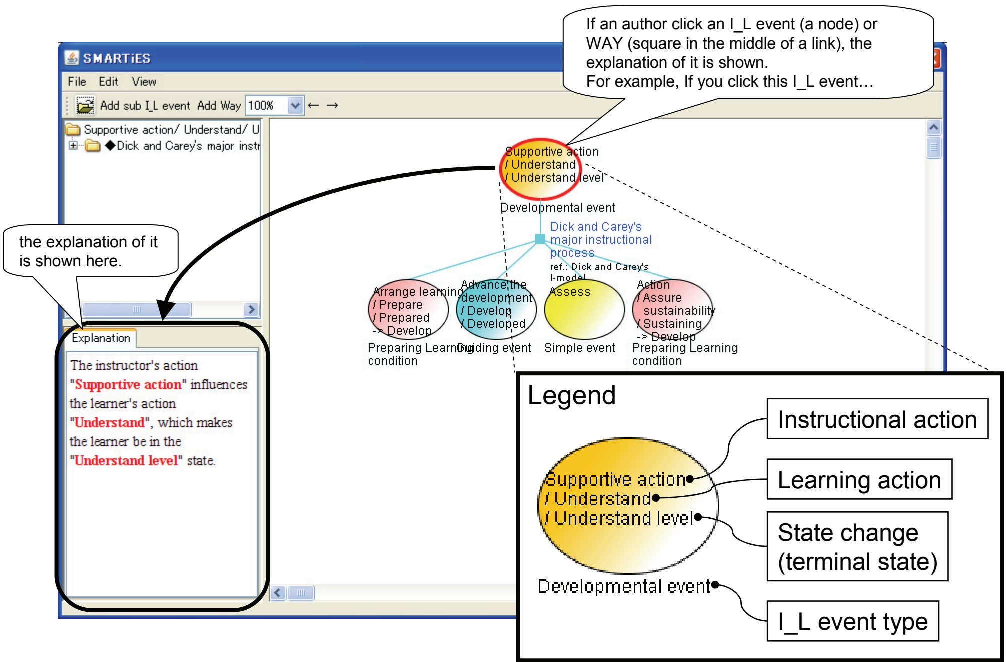

The main window of SMARTIES (2/2)

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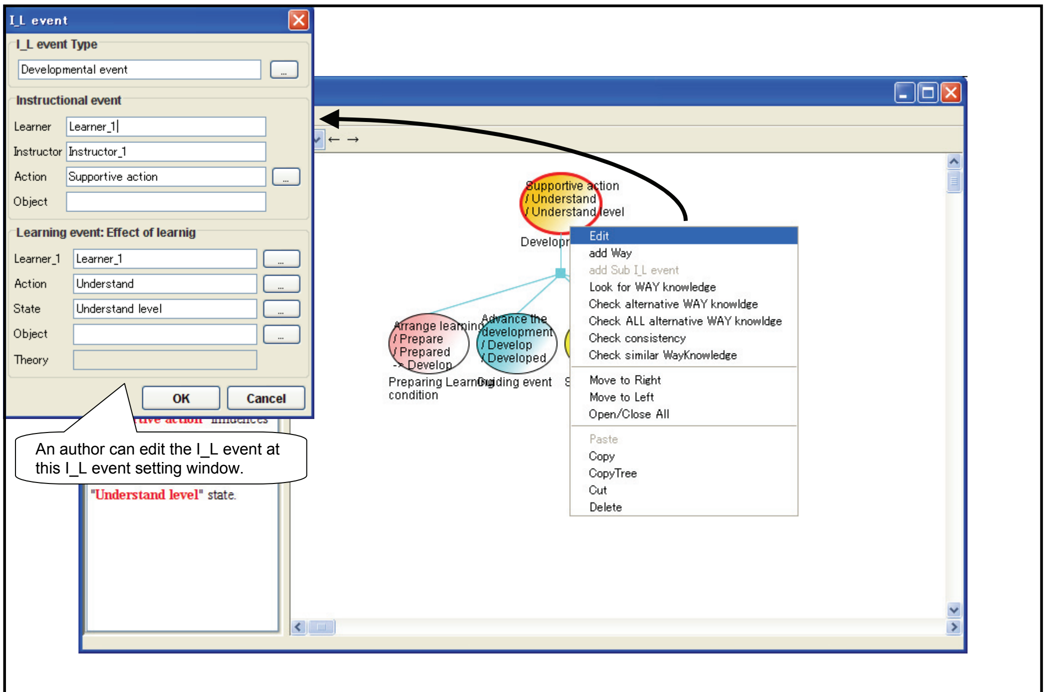

I_L event editing (1/3)

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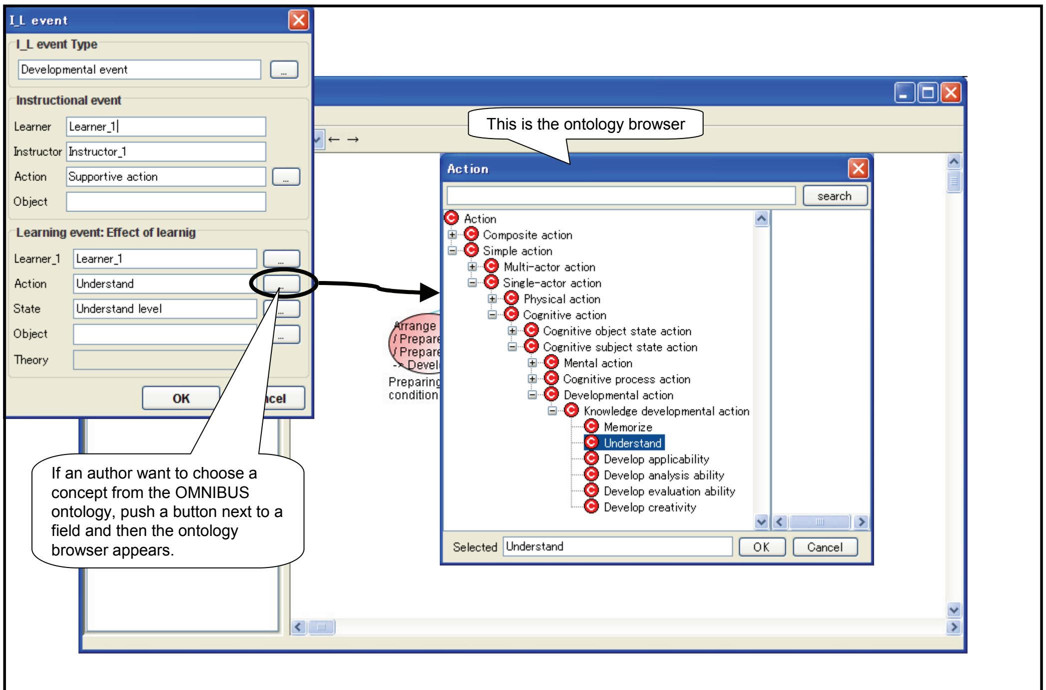
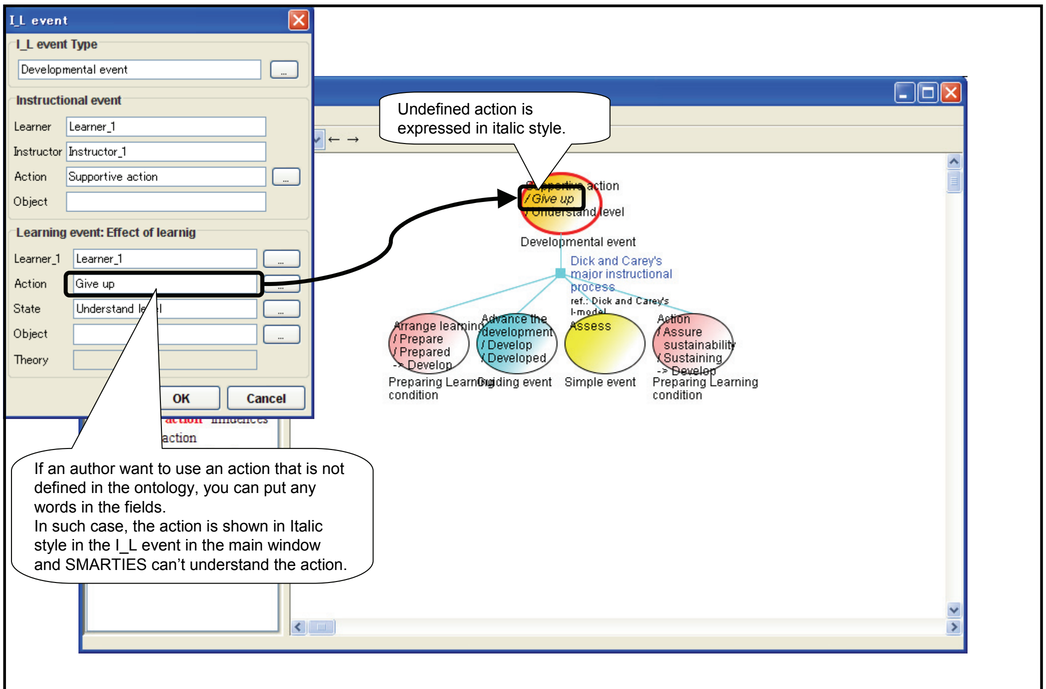


I_L event editing (2/3)

20



I_L event editing (3/3)

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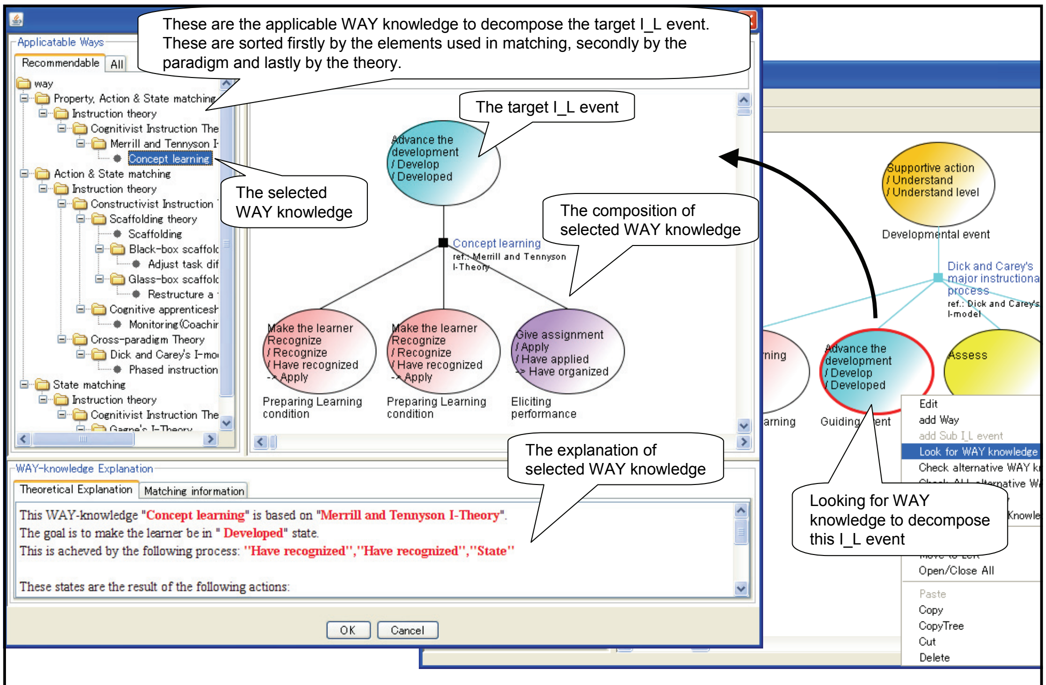

Looking for WAY knowledge to decompose an I_L event

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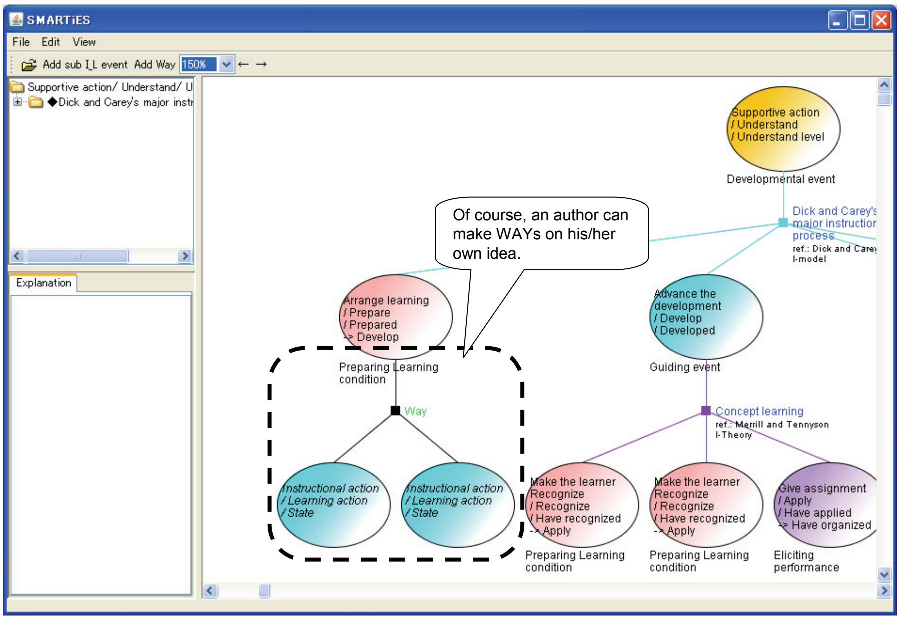
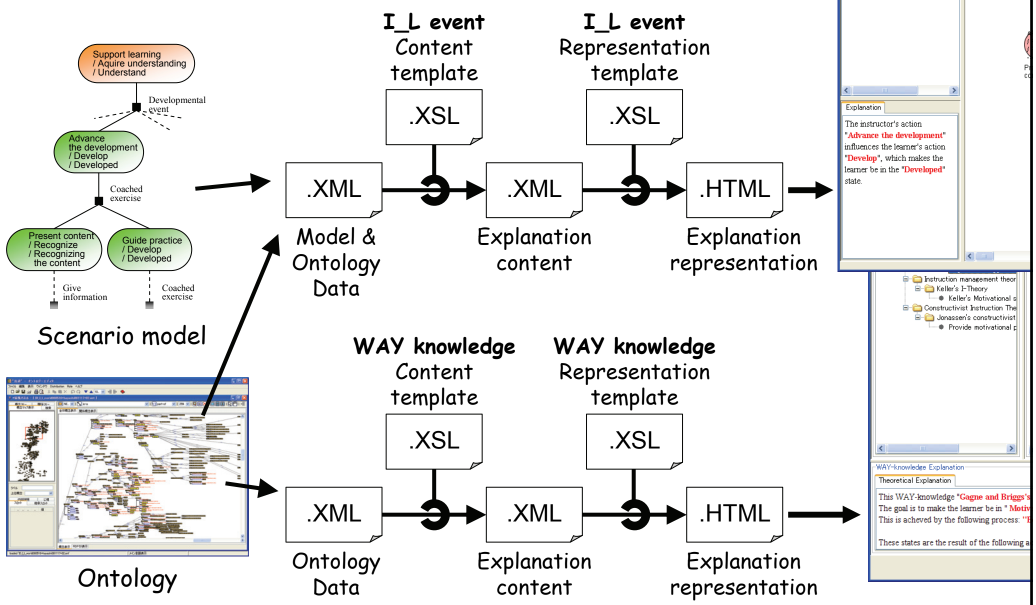


Making WAYs on an author's own idea

Generation mechanism of explanation



Demonstration of SMARTIES (2/3)

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Sample scenario

- **From**

  Charles M. Reigeluth (Eds.)
  "Instructional Theories in Action
  Lessons Illustrating Selected Theories and Models"
- **Based on Gagne's theory**
  - **Target is** Intellectual skill
    "Use a previously unencountered optical micro scope properly"
- **Demonstration the following theory-aware functionality**
  - Blending multiple theories into a scenario
  - Finding similar theories to an author's own strategy
  - Consistency check of scenario-flow

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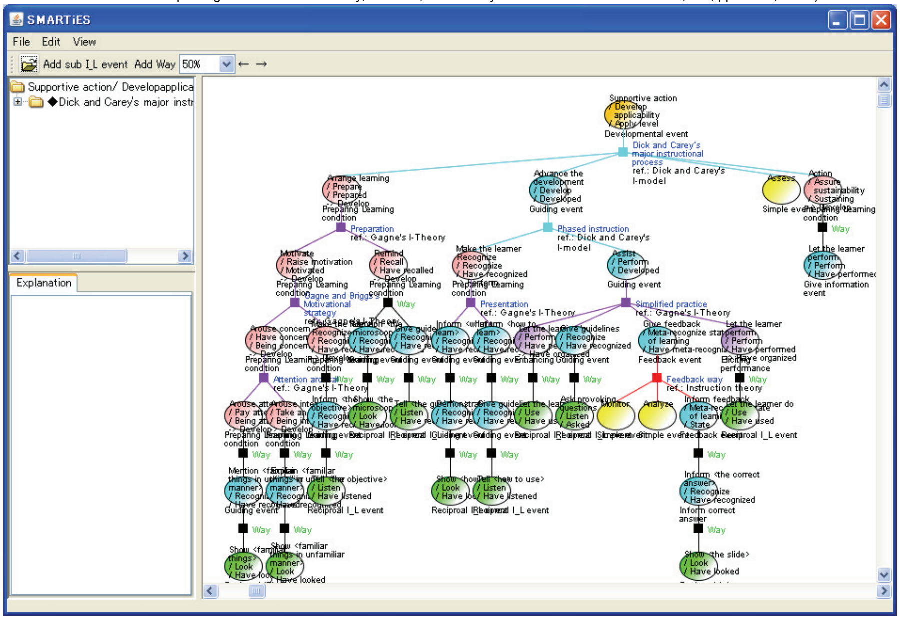
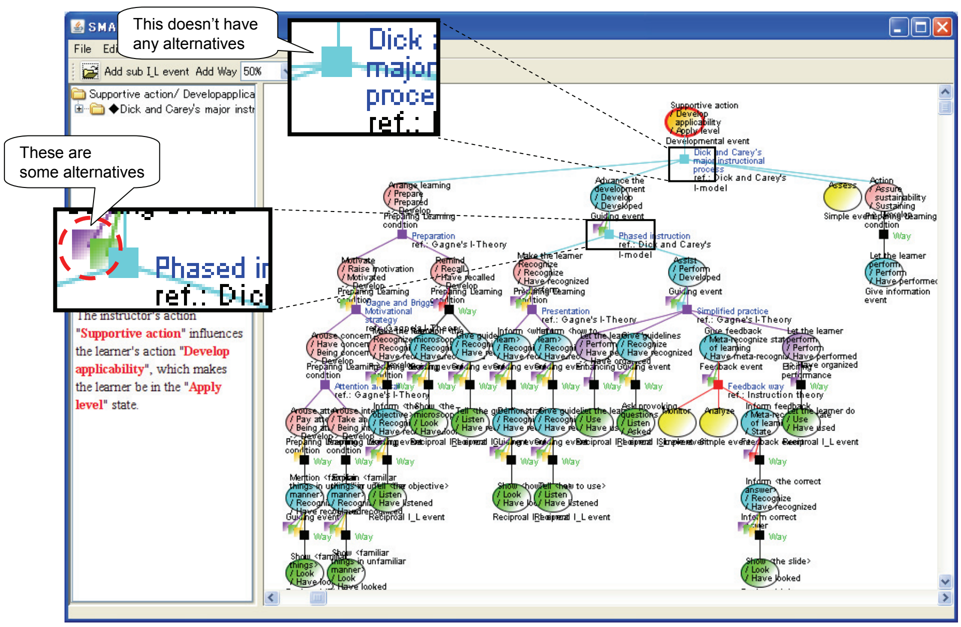
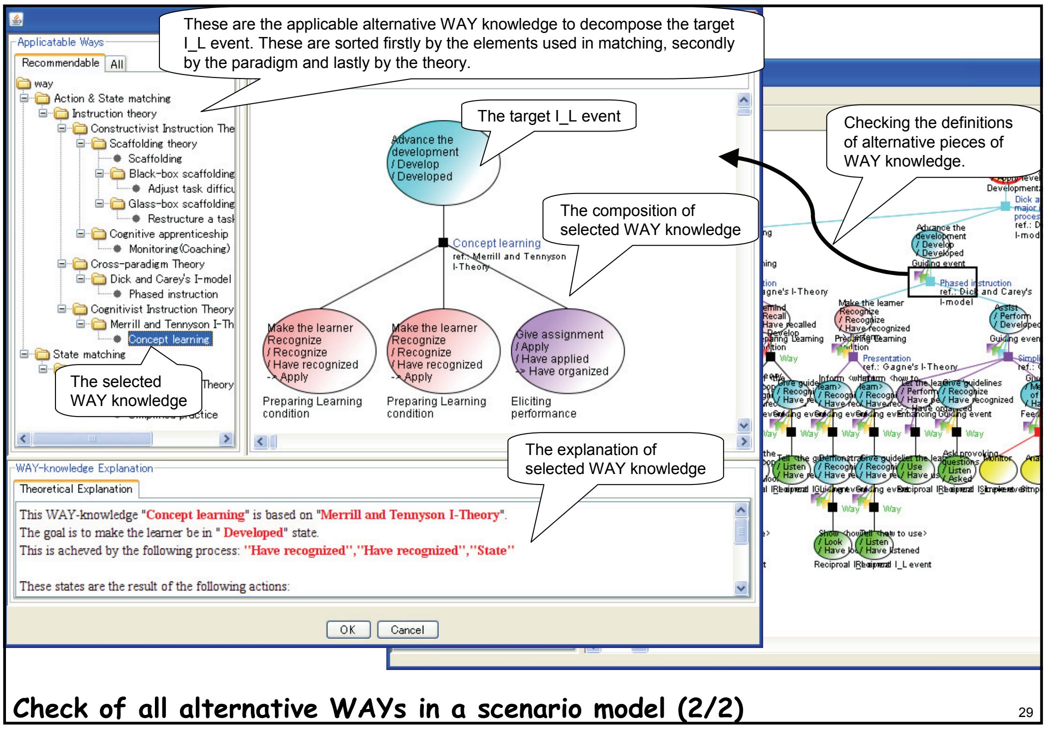
(From Perty, B., Mouton, H., Reigeluth, C. M.: “A Lesson Based on the Gagne’-Briggs Theory of Instruction”, in Reigeluth, C. M. (Eds.): Instructional-design theories and models A new paradigm of instructional theory, Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc., pp. 11-44, 1999.)



Overview of the sample scenario model based on Gagne-Briggs theory.



Check of all alternative WAYs in a scenario model (1/2)


These are the applicable alternative WAY knowledge to decompose the target I_L event. These are sorted firstly by the elements used in matching, secondly by the paradigm and lastly by the theory.
The target I_L event
Checking the definitions of alternative pieces of WAY knowledge.
The composition of selected WAY knowledge
The selected WAY knowledge
The explanation of selected WAY knowledge
Applicable Ways
Recommendable
All
WAY-knowledge Explanation
Theoretical Explanation
This WAY-knowledge "Concept learning" is based on "Merrill and Tennyson I-Theory".
The goal is to make the learner be in " Developed" state.
This is acheved by the following process: "Have recognized","Have recognized","State"
These states are the result of the following actions:
OK
Cancel
Check of all alternative WAYs in a scenario model (2/2)
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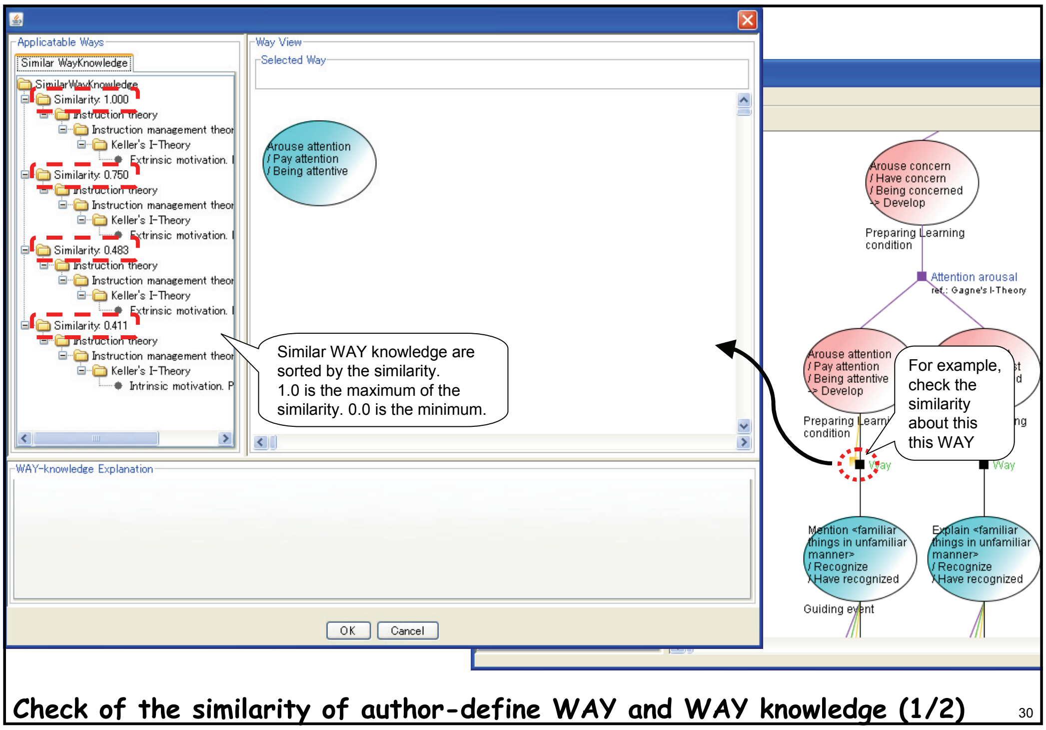
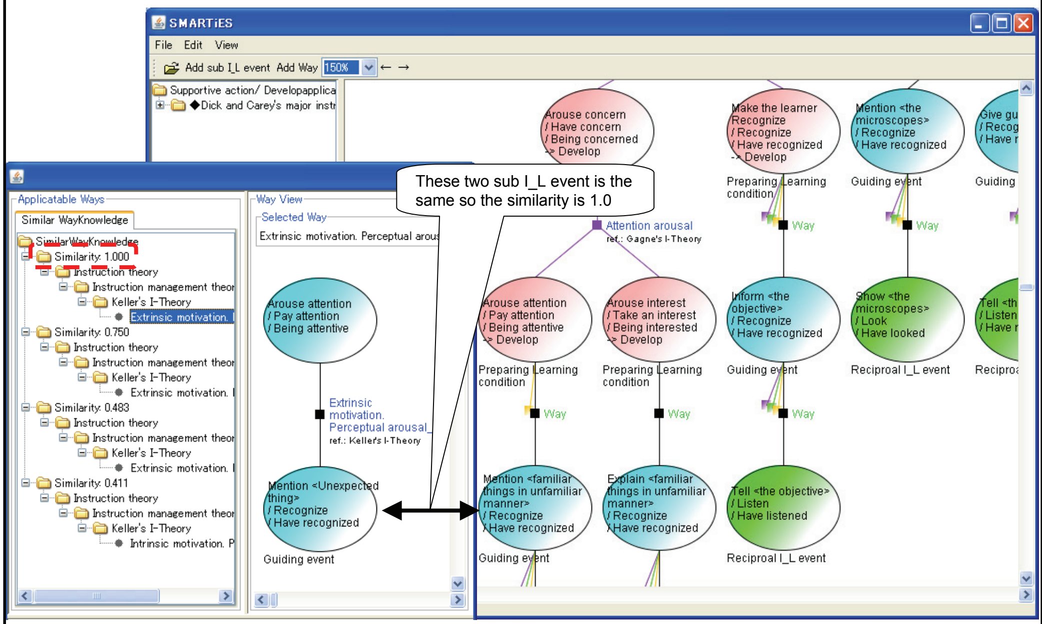

Applicable Ways
Similar WayKnowledge
Similarity: 1.000
Similarity: 0.750
Similarity: 0.483
Similarity: 0.411
Way View
Selected Way
Arouse attention / Pay attention / Being attentive
Similar WAY knowledge are sorted by the similarity. 1.0 is the maximum of the similarity. 0.0 is the minimum.
For example, check the similarity about this WAY
WAY-knowledge Explanation
OK
Cancel
Check of the similarity of author-define WAY and WAY knowledge (1/2)
30



Check of the similarity of author-define WAY and WAY knowledge (2/2)

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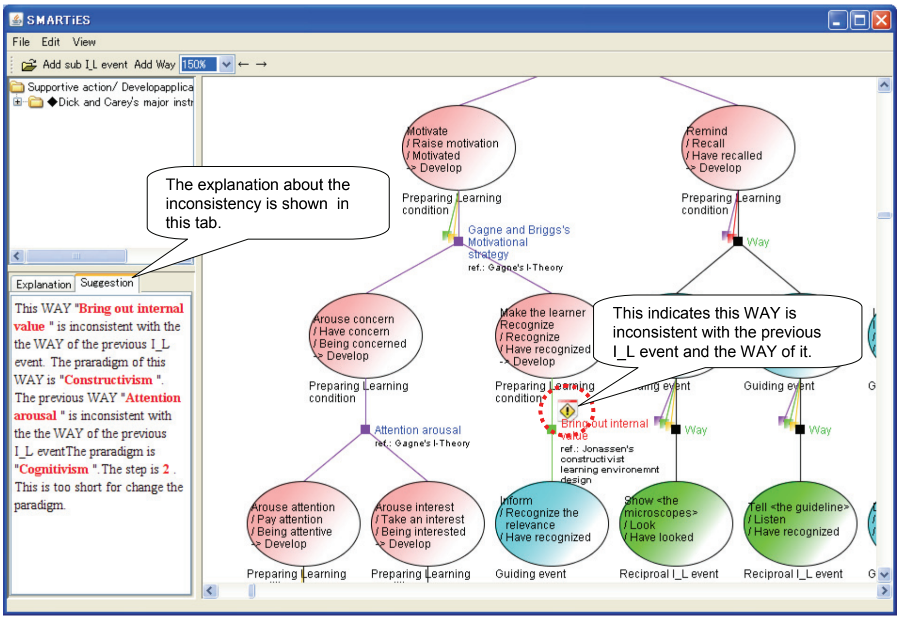

Consistency check of the scenario sequence (1/2)

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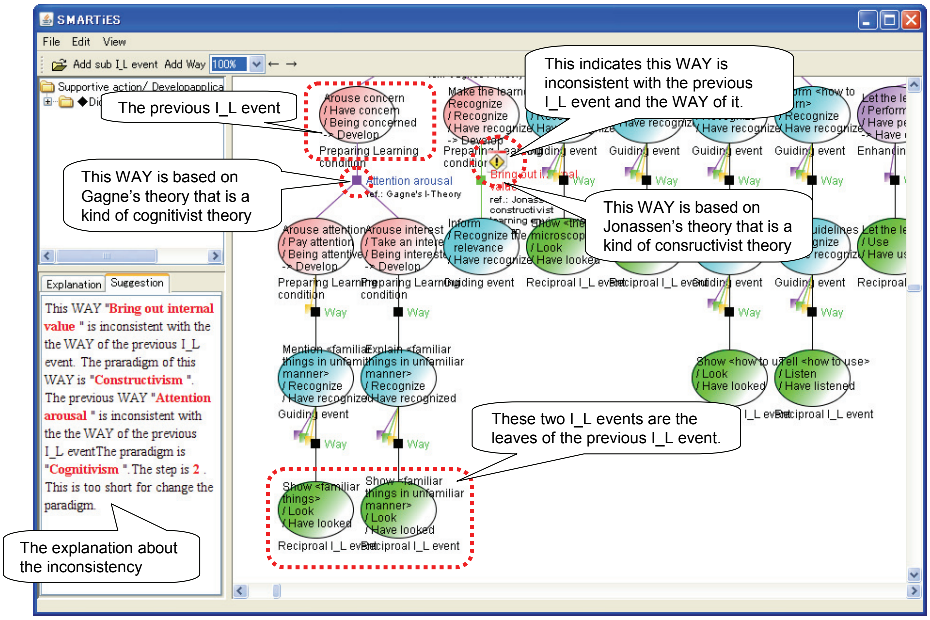

Consistency check of the scenario sequence (2/2)

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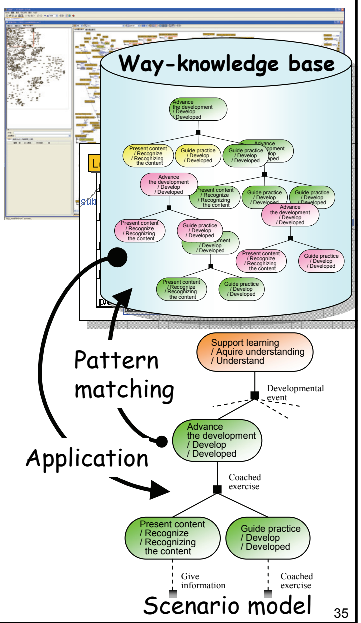
Inside of SMARTIES

- **Basic functionality** of SMARTIES
  1. Read and write the ontology
  2. I_L event pattern matching
     (and unfolding scenario model)
  3. Rule-based reasoning
     - E.g. Scenario consistency check rule
       – all the data used in the rule is defined in the ontology
- **Declarative definition of concepts in the ontology**
- **All the theories and scenarios in SMARTIES are modeled based on the ontology**



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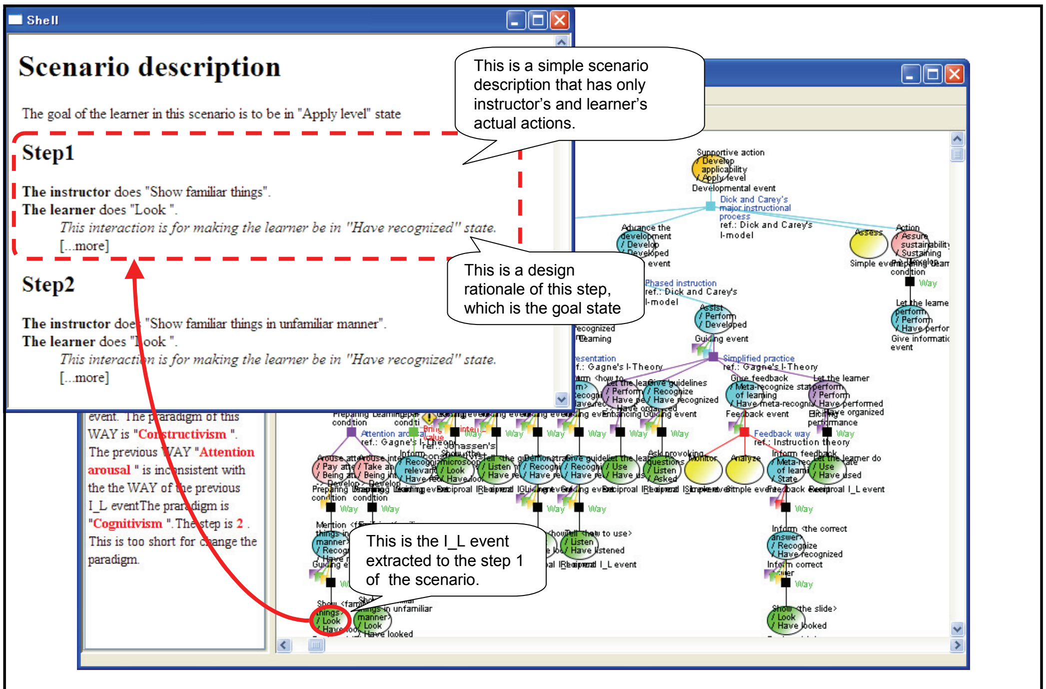

Export of simple scenario description (1/2)

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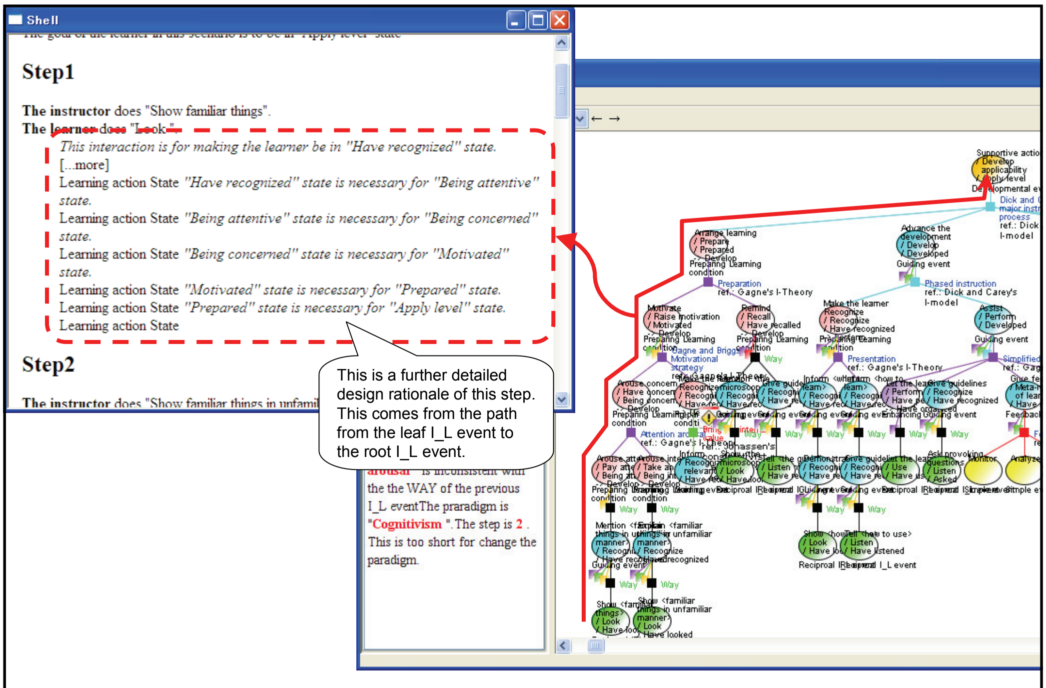

Export of simple scenario description (2/2)

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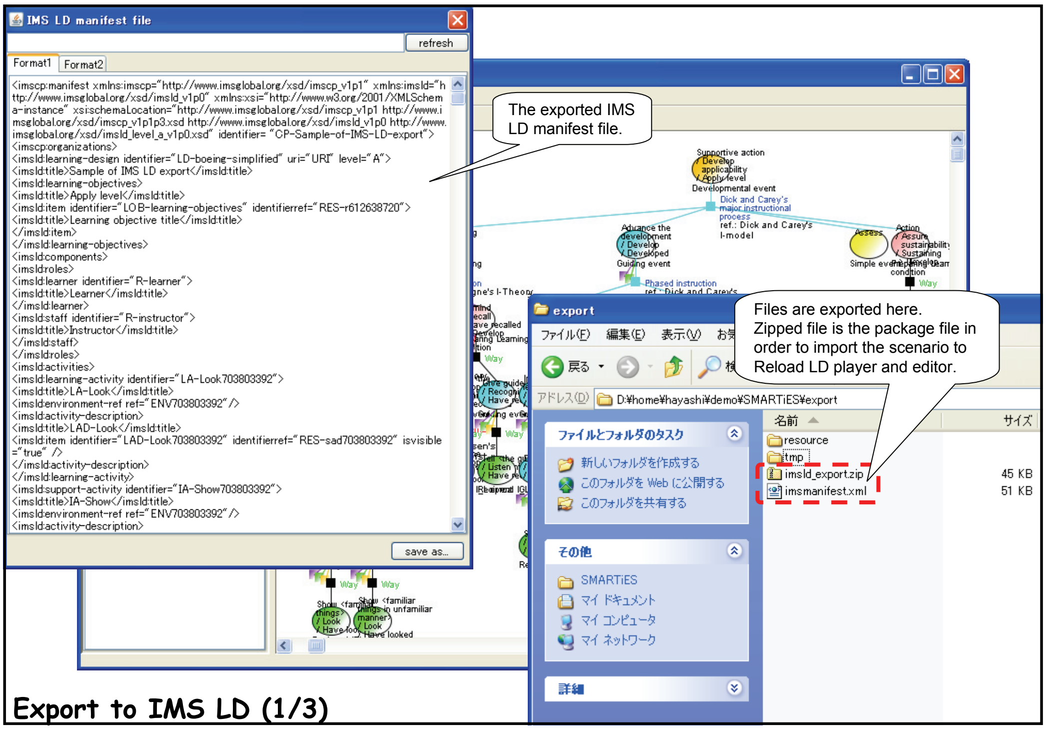
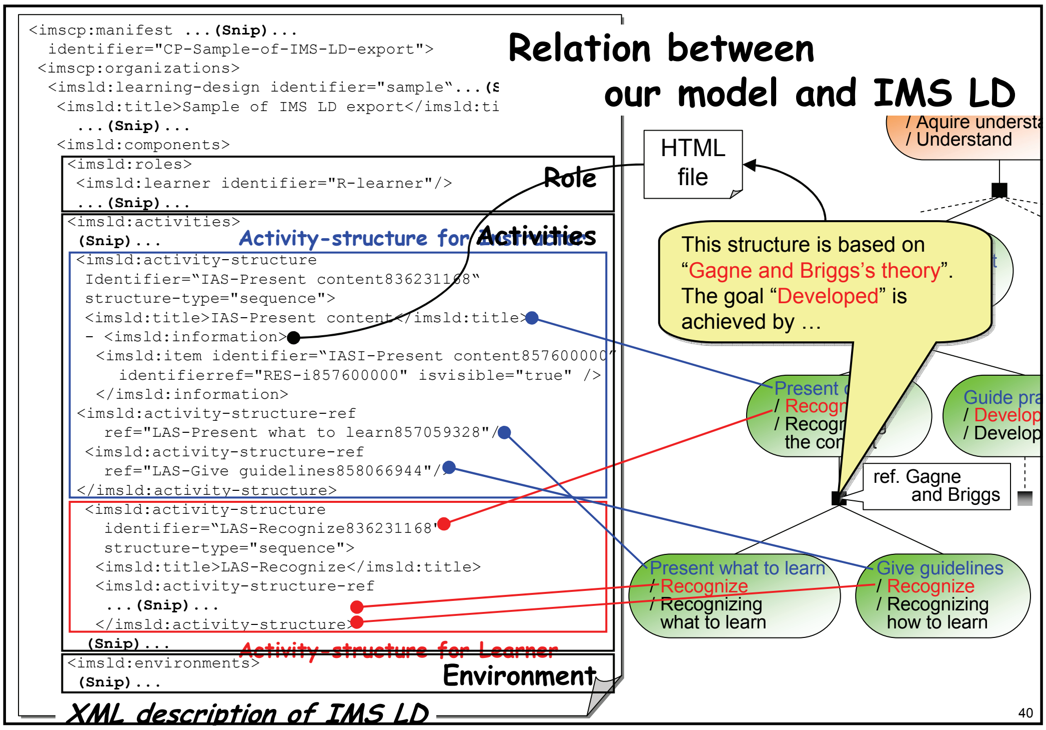

IMS LD manifest file
refresh
Format1
Format2
save as...
The exported IMS LD manifest file.
Files are exported here.
Zipped file is the package file in order to import the scenario to Reload LD player and editor.
export
D:¥home¥hayashi¥demo¥SMARTiES¥export
resource
tmp
imsld_export.zip
imsmanifest.xml
45 KB
51 KB
Export to IMS LD (1/3)


Relation between
our model and IMS LD
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...(Snip)...
<imsld:components>
<imsld:roles>
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...(Snip)...
Role
<imsld:activities>
(Snip)...
Activity-structure for Activities
<imsld:activity-structure
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- <imsld:information>
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</imsld:information>
<imsld:activity-structure-ref
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ref="LAS-Give guidelines858066944"/>
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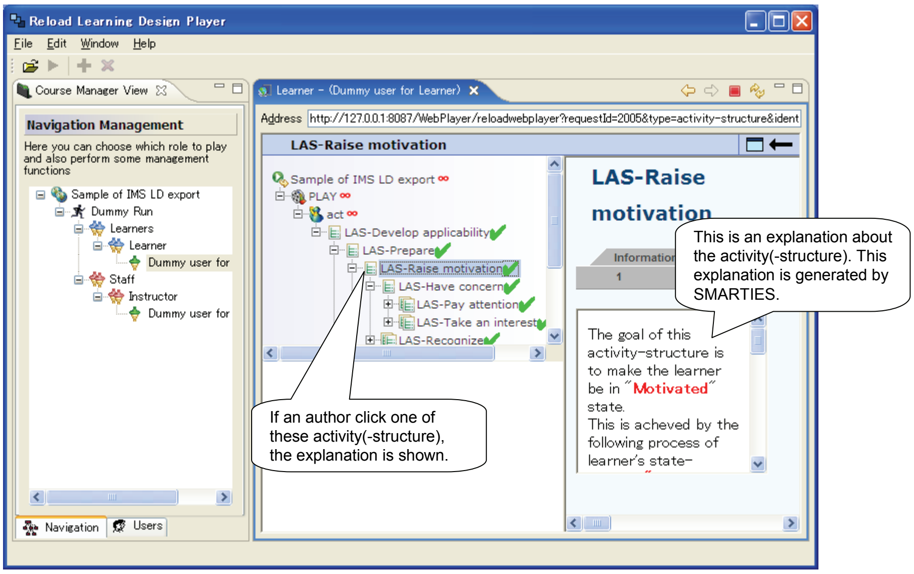
<imsld:activity-structure-ref
...(Snip)...
</imsld:activity-structure>
(Snip)...
Activity-structure for Learner
<imsld:environments>
(Snip)...
Environment
XML description of IMS LD
HTML file
/ Aquire understa
/ Understand
This structure is based on "Gagne and Briggs's theory". The goal "Developed" is achieved by ...
Guide pra
/ Develop
/ Develop
ref. Gagne and Briggs
Present what to learn
/ Recognize
/ Recognizing what to learn
Give guidelines
/ Recognize
/ Recognizing how to learn
40



Export to IMS LD (2/3)

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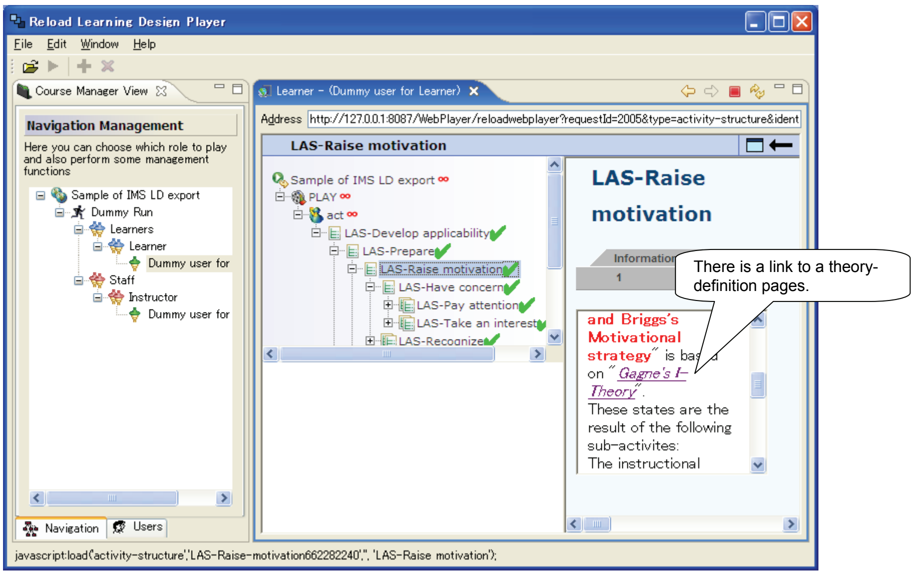

Export to IMS LD (3/3)

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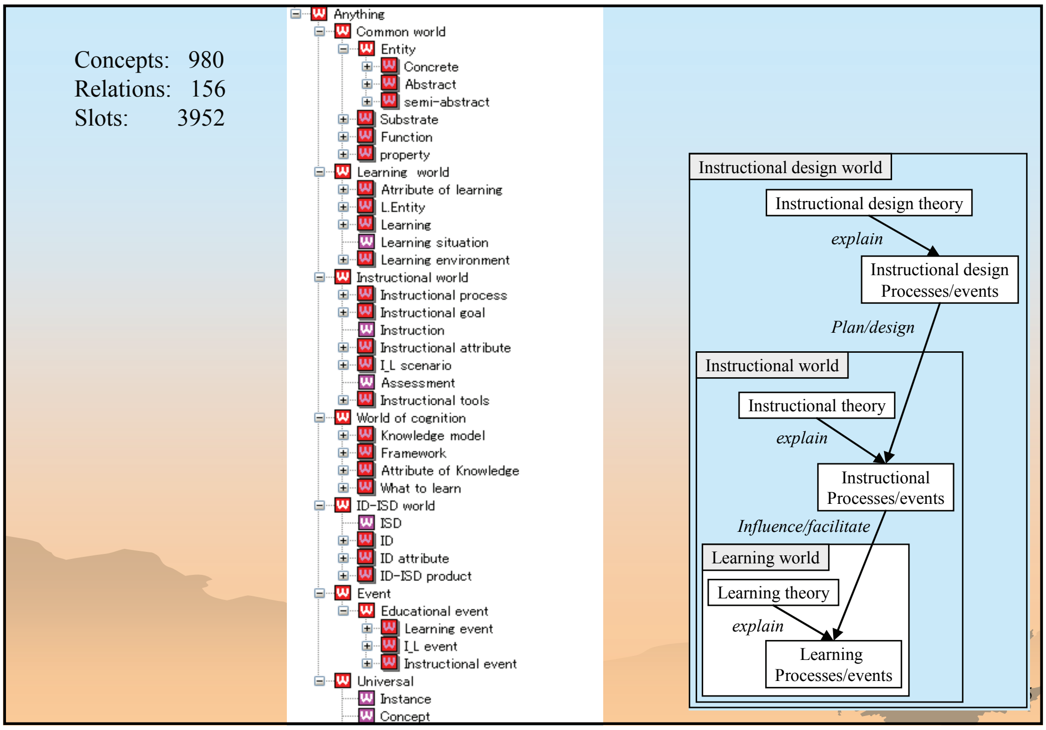
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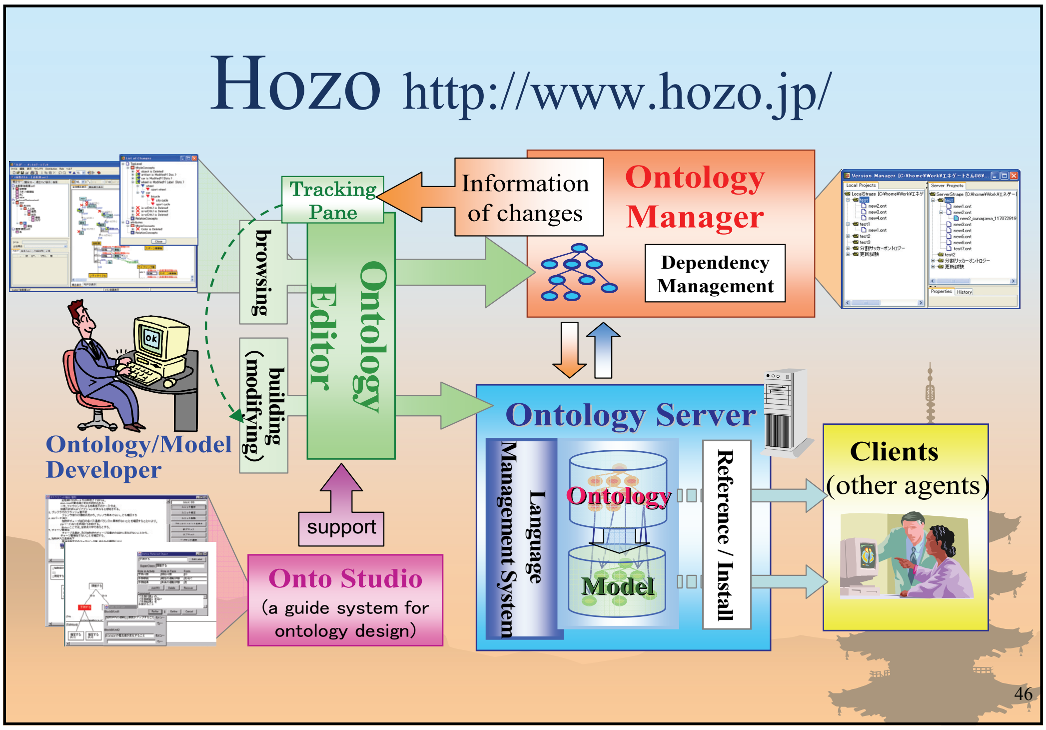
Relations: 156
Slots: 3952
Anything
Common world
Entity
Concrete
Abstract
semi-abstract
Substrate
Function
property
Learning world
Atrribute of learning
L.Entity
Learning
Learning situation
Learning environment
Instructional world
Instructional process
Instructional goal
Instruction
Instructional attribute
I_L scenario
Assessment
Instructional tools
World of cognition
Knowledge model
Framework
Attribute of Knowledge
What to learn
ID-ISD world
ISD
ID
ID attribute
ID-ISD product
Event
Educational event
Learning event
I_L event
Instructional event
Universal
Instance
Concept
Instructional design world
Instructional design theory
explain
Instructional design Processes/events
Plan/design
Instructional world
Instructional theory
explain
Instructional Processes/events
Influence/facilitate
Learning world
Learning theory
explain
Learning Processes/events


Hozo http://www.hozo.jp/
Tracking Pane
Information of changes
Ontology Manager
Dependency Management
browsing
building (modifying)
Ontology Editor
Ontology/Model Developer
support
Onto Studio
(a guide system for ontology design)
Ontology Server
Language Management System
Ontology
Model
Reference / Install
Clients
(other agents)
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Building a heavy-weight ontology

- Goal
  - To find an **ontological model** of learning/instructional/ID theories for building an **engineering infrastructure** for making computers **theory-aware**
- Research issues for building such an ontology
  - What is an engineering **infrastructure** on which we can represent common and different features of various theories?
  - How to cover **declarative and procedural** aspects of theories
  - How to "***operationalize***" theories so that computers can help authors describe appropriate scenarios which are ***theory-compliant***
  - What is the **core** of such an ontology?
  - How to model basic actions and context-dependent actions
  - **All concepts used by application programs must be properly defined in the ontology**

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Basic issues and policies

- Declarative aspects
- Actions and Events
  - All (generic) actions are classified in the Common world
  - All contextual actions are classified with the I/L context under **Educational Event** class
  - No action or process is in Learning and Instructional worlds
- Procedural aspect of theories
  - Clear distinction between **state-based actions** and **motion-based actions** (primitive)
  - Theory consists of Strategies
  - Strategy is modeled as ***Action decomposition tree***
- Role issue
  - Learning goal is defined as a ***Role holder*** in the **Learning** with the class constraint: **What to learn**
  - **Instructional goal** is defined explicitly

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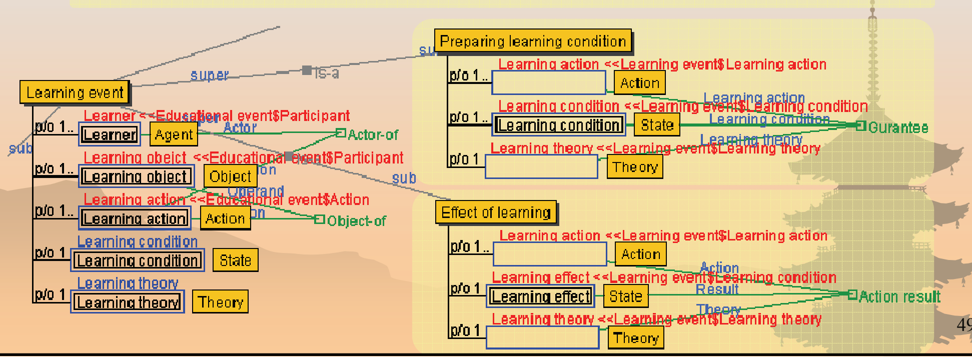
Basic interpretation of learning theories

- Learning theories describe
  - A few conditions which guarantee that a learning action is effective
  - Learning benefits of a learning action
- Reflecting learning theories to learning event
  - Preparing learning conditions
    - When learning conditions are satisfied, the learning theory guarantees the learning action is successful.
  - Effect of learning
    - A learning theory can tell us what effect is expected after a learning action.



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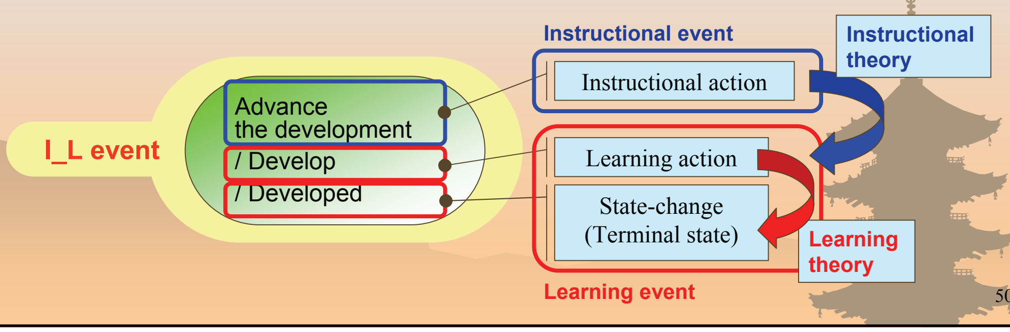
Core model
of learning/instructional events

- The difficulty in modeling instruction and learning might be that the change is achieved by two kinds of actions:
  - Instructional actions leads a learner to do some sort of learning actions
  - Learning actions cause the change of learner's state.
- The key points of our conceptualization are
  - to emphasize the relation among the three and
  - to model a contribution of instructional action on the change of learner's state.



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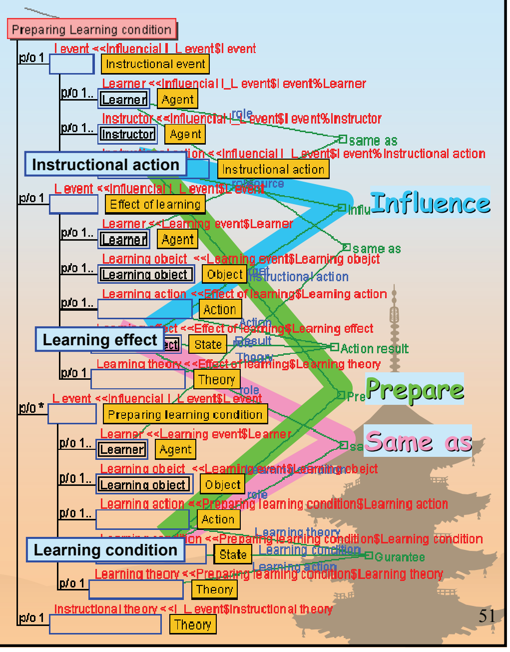
Implementation of the core model (I_L event)

- Instructional theories prescribe effective instructional processes for intended learning processes.
  - Relation between instructional events and learning events can be supported by instructional theories.
- Two viewpoints of relations between learning and instruction
  - An instructional action influences or facilitates learning actions.
    - Then the learning actions achieve state-changes of learner.
  - An instructional action prepares the following learning events.
    - The instructional action satisfies the necessary conditions of the following learning actions.



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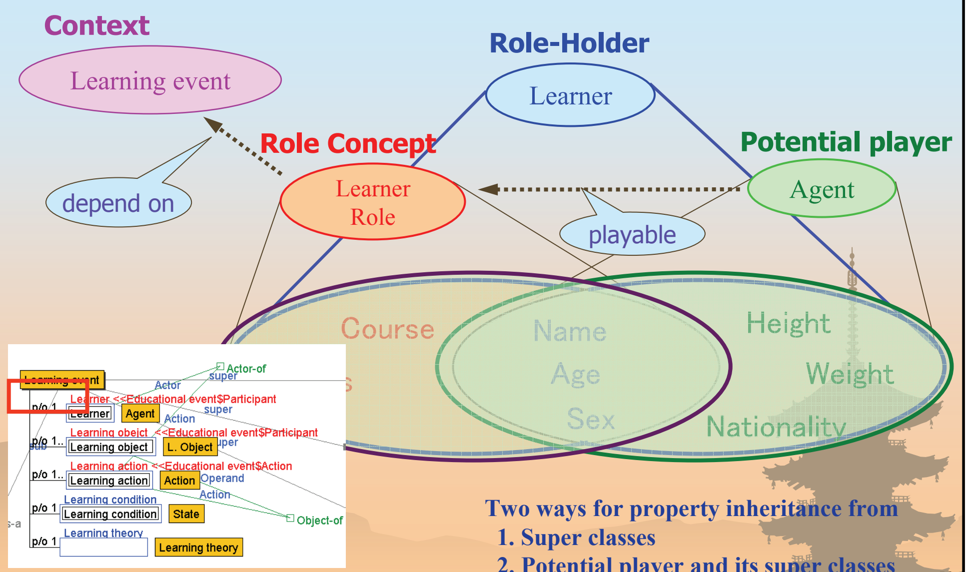
Conceptual Framework of Role



Two ways for property inheritance from

1. Super classes
2. Potential player and its super classes

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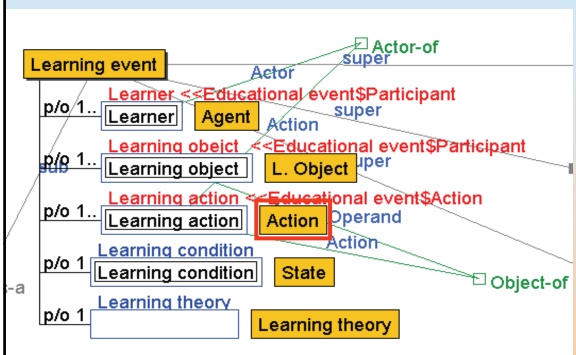

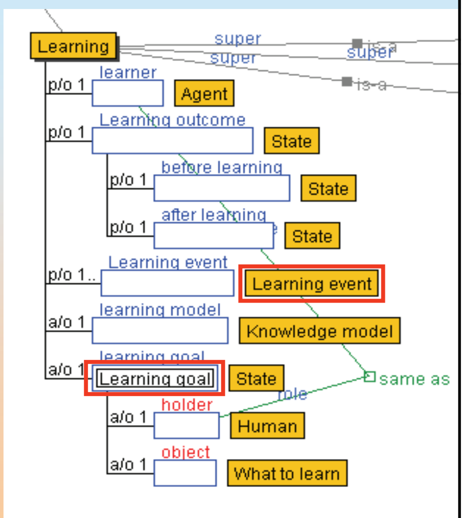

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Basic issues and policies

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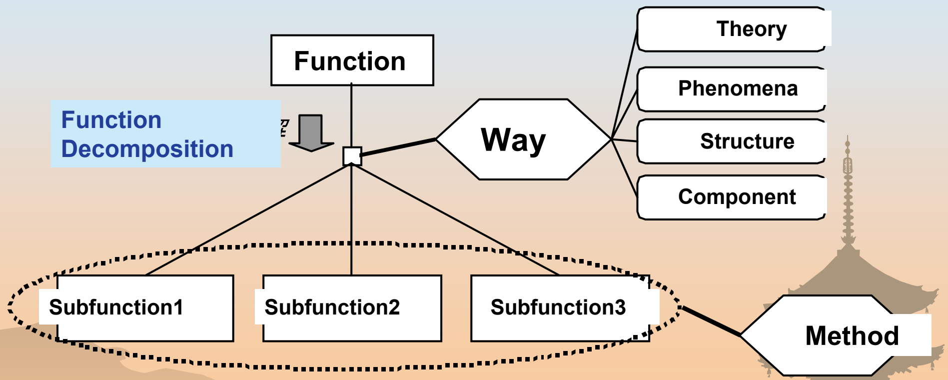
Function decomposition



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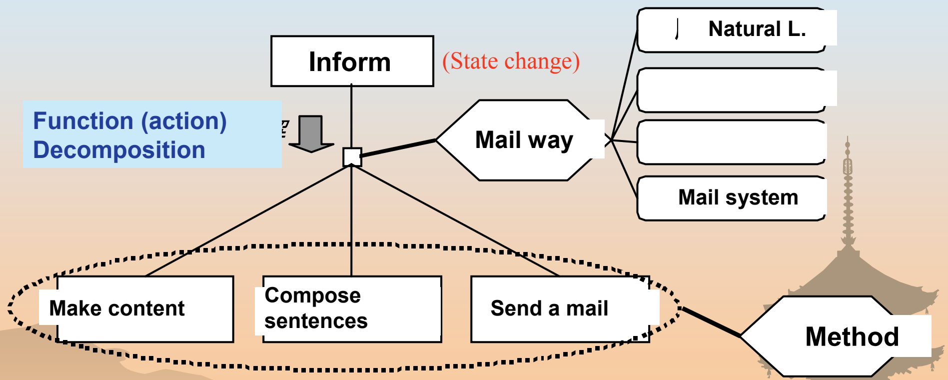
Function(Action) decomposition

- Example -



Basic issues and policies

- Declarative and procedural aspects
- Actions and Events
  - All actions are classified in the Common world
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- Procedural aspect of theories
  - Theory consists of Strategies
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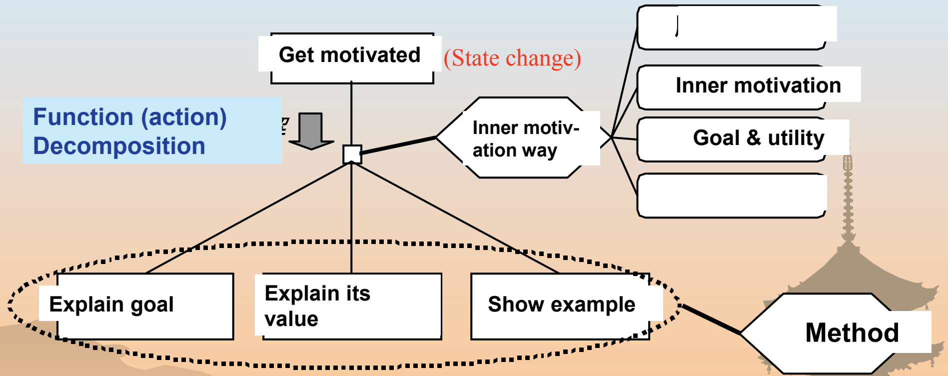
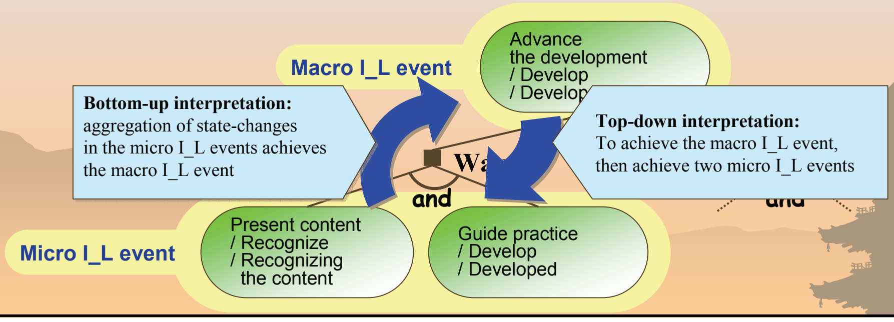
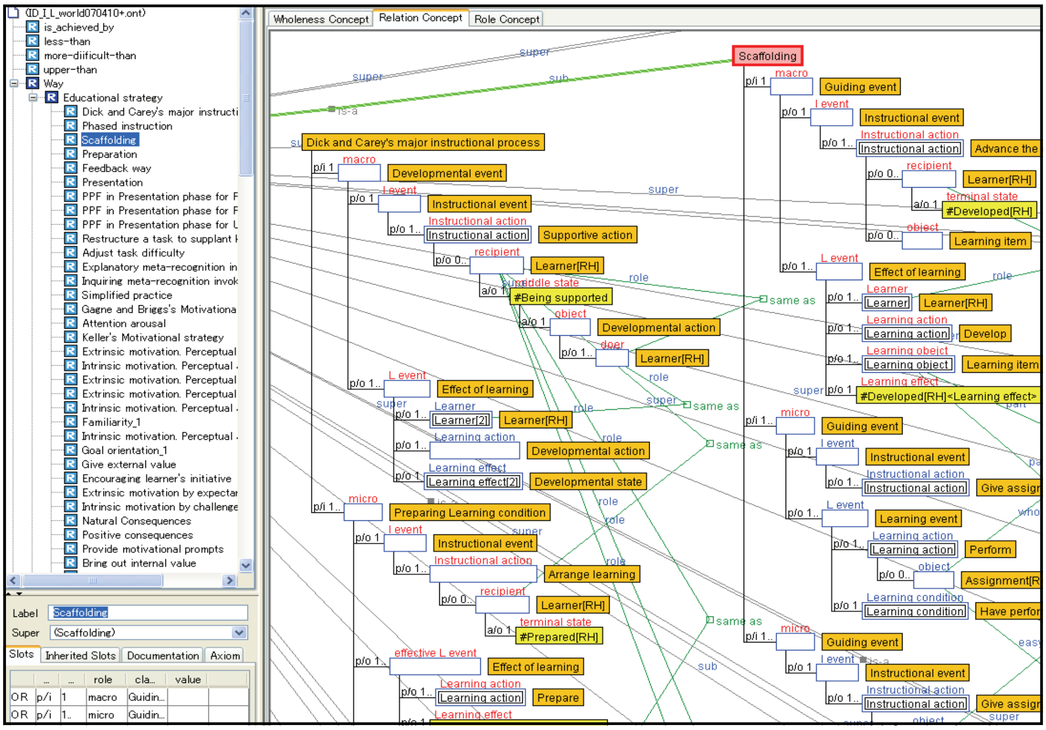
Function(Action) decomposition
- Example -



Framework of capturing strategies and its sophisticated use

- Modeling of ways to achieve a goal (state change)
  – A Way is conceptualized as a relation of decomposition and achievement between **macro I_L event** and **micro I_L events**
- A goal can be usually achieved in several ways
  – There may be different ways to achieve the same goal (state-change of a learner).
  – Theories give different ways to achieve goals as strategies.





Possibility of a comprehensive ontology which covers theories and paradigms

- Considerations for commonality and difference between paradigms and theories
  - In the first place, each paradigm/theory has its own definition of "Learning"...?

  But...
  - Although many theories prescribe the same method for the same situation, these are described in different terminology [Reigeluth 83].
  - Although behaviorism, cognitivism and constructivism each has many unique features, they describe the same phenomena of "learning" [Ertmer 93].

- Our **Working hypothesis** for building a comprehensive ontology
  - Every theory rests somehow on the common basis of explaining learning and instruction.
  - While the assumed mechanism of developing knowledge is different for each paradigm, the idea of states in the learning process is common.

  There must be an ***engineering approximation*** of the states where we can conceptualize "Learning" by change of learner's state.

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The key issue is State of learners

- Internal State
- External state

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- Agent state
  - Internal state
    - Cognitive process state0
      - Cognitive process state for WM
        - Meta-cognitive process state
          - Expecting the success of learning
          - Have meta-recognized
        - Cognitive process state
      - Cognitive process state for LTM
    - Attitudinal state
      - Motivation
      - Confidence
      - Satisfaction
      - Being concerned
      - Readiness
      - Expectation
      - Affinity
      - Assenting
      - Familiarity
        - Feeling familiarity
        - Not feeling familiarity
    - Progression state
      - Achievement state
        - With trouble in learning
        - Result
    - Developmental state
      - Knowledge state
      - Psychomotor-skill state
        - Domain skill state
        - Cognitive skill state
        - Perception level
        - Set level
        - Guided Response level
        - Mechanism level
        - Complex Overt Response level
        - Adaptation level
        - Origination level
  - External state
    - Communicative state

- External state
  - Communicative state
    - Passive com. state
      - Continuous passive com. state
        - Beeing taught
        - Being supported
      - Resultant passive com. state
        - Reminded
        - Recieved
        - Have been taught
        - Informed
          - Directed
            - Requested
            - Led
          - Transmitted
        - Evaluated
        - Monitored
        - Analysed
        - Diagnosed
        - Assigned
    - Active com. state
      - Continuous active com. state
        - Developing
        - Preparing
        - Supporting
        - Seeking
      - Resultant active com. state
        - Have answered
        - Have performed
        - Have reflected
  - Physical state
    - Solving a problem
    - Performing a task
- Object state
  - Used
  - Generated
  - Representated
  - Existance
  - Recognized
  - Meta-recognized

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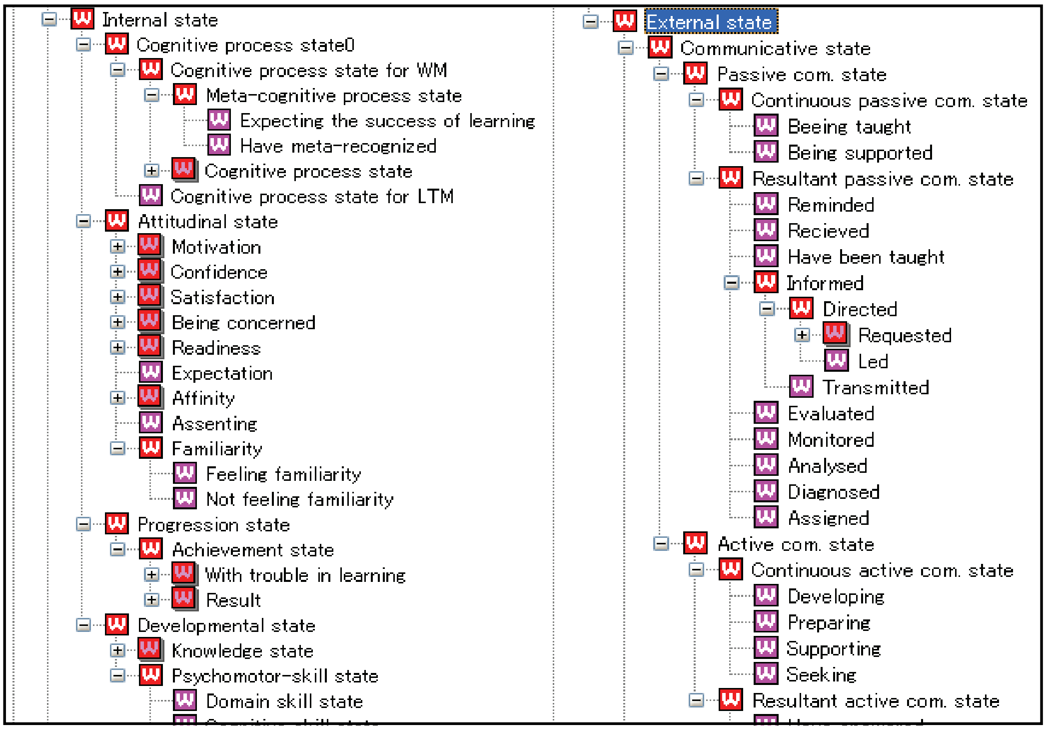

Statistics of state usage across theories

	A	B	C	D	E
1		Cross-paradigm theory	Constructivist theory	Cognitivist theory	Instruction management theory
2	num. of thoeries	1	5	3	1
3	num. of WAY knowledge	2	33	30	16
4	num. of events	5	39	40	23
5					
6	Cognitive state (%)	20.0	30.8	67.5	47.8
7	Meta-cognitive state (%)	0.0	51.3	17.5	21.7
8	Attitude state (%)	0.0	2.6	12.5	30.4
9	External state (%)	0.0	15.4	2.5	0.0

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Summary of OMNIBUS ontology
– Computational aspect –

- Theories are decomposed into **way knowledge** as strategies
- Way knowledge consists of macro **I_L event** and micro **I_L events**
- An I_L event consists of chunks of **I event** and **L events**
- All events are defined as **composite of participants and actions** with resulting **state change**
- **Actions** are defined context-independently

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Summary of OMNIBUS ontology
– Declarative aspect –

- ***is-a*** hierarchies of
  - Theories
  - Actions
  - States
  - Events
- ***Way knowledge*** is also organized in an ***is-a*** hierarchy
- Knowledge world with paradigms of learning/instructional theories

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SMARTIES

- Theory-compliant authoring of scenarios
- Standards(IMS-LD)-compliant output
- Theory blending
- Explanation generation
- Feedback based on evaluation of the scenario

Future work

- Exploiting properties
- Linkage of LOs

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