Utilizing AI Technologies for Human Learning Processes

A First Step and a Vision

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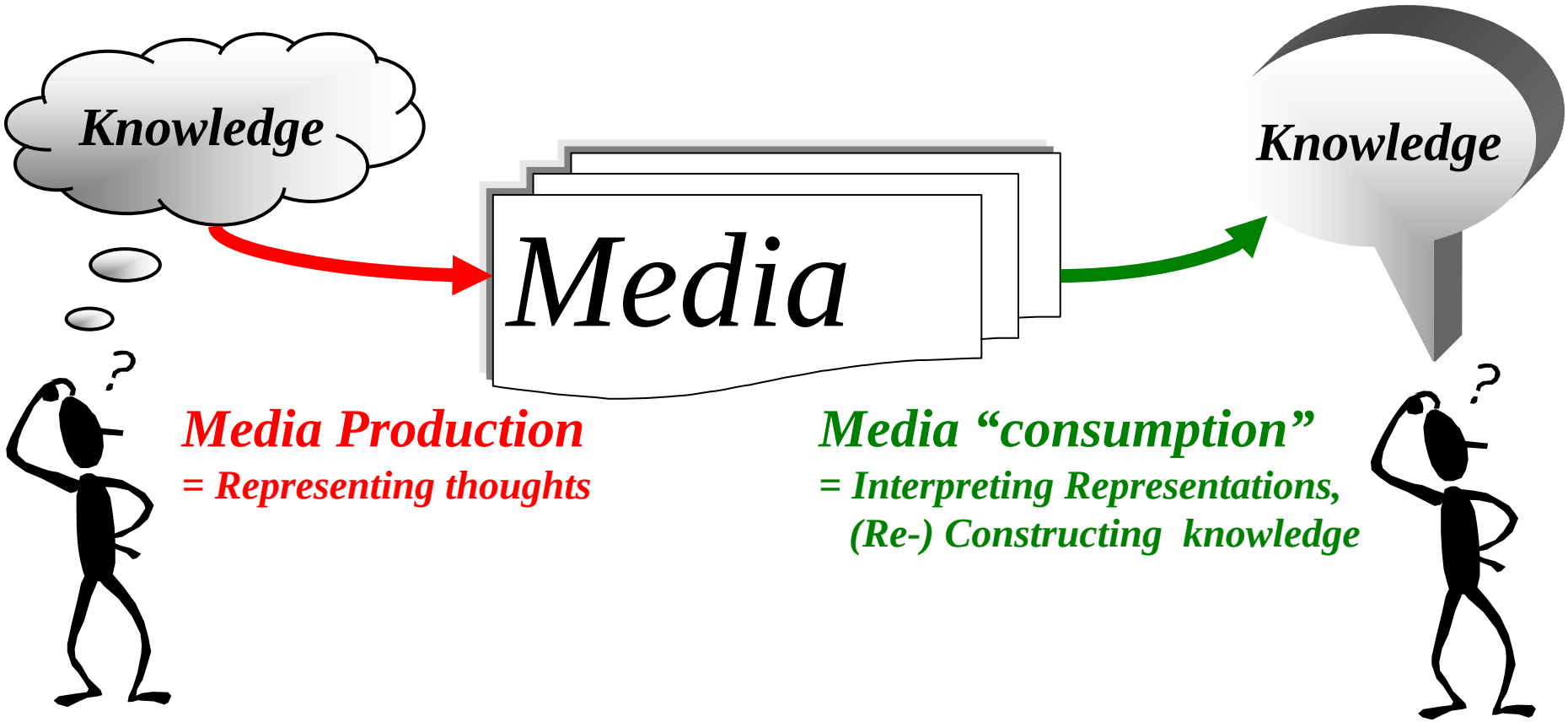
1 What's knowledge?

How to transmit knowledge?



Media Production
= Representing thoughts

Media "consumption"
= Interpreting Representations,
(Re-) Constructing knowledge

Knowledge Media Science $\cong$ *Art of*

- *Producing appropriate media from knowledge* +
- *Deriving knowledge from appropriate media*

2 What is DIDACTICS ?

= *(meta) knowledge about proper knowledge transmission*

- Completely informal (so far)
- Much of it is not represented at all *(just utilized by experienced teachers)*

- *Let's make explicit what we talk about!*
  ⟹ (semi-) formal **represent** didactics
- *Let's apply such representations in (our university) practice!*
  ⟹ enable also non-experts in didactics to **process** a model of didactics
- *Let's explore conditions that can be (formally) checked: consistency conditions, invariants, didactical principles, … !*
  ⟹ **verify** didactic knowledge
- *Let's check the result of applying certain didactics in a case study!*
  ⟹ **validate** applied didactics based on the degree of success
- *Let's learn from the validation results!*
  ⟹ **refine** didactic knowledge towards incremental improvement
- *Let's derive successful didactic patterns!*
  ⟹ **learn** didactic patterns inductively from successful and failing examples
- *Let's utilize these patterns!*
  ⟹ **support** didactics by a design tool with a pattern library

our approach towards doing the above

Storyboarding - a modeling concept for Didactic Knowledge

3.1 Storyboarding – What's the objective?

Objectives and differences to concepts so far:

- ✓ **driven by human learning activities**
  - ¬ not by software-technological concepts
- ✓ **supporting the development of IT enhanced learning**
  - ¬ not the design of e-learning systems
- ✓ **organizing learning experience**
  - ¬ not learning materials
- ✓ **concentration on the learners' activities**
  - ¬ not on the use of e-learning systems

More generally, technological progress …

- ✓ … has to support the satisfaction of natural human wishes (like learning, e.g.) by providing tools that help to perform appropriate activities and
  - ¬ … must not force humans to adapt their natural desires and activities to current (software-) technological standards or tools.

Requirements to the Storyboard approach to support didactic design:

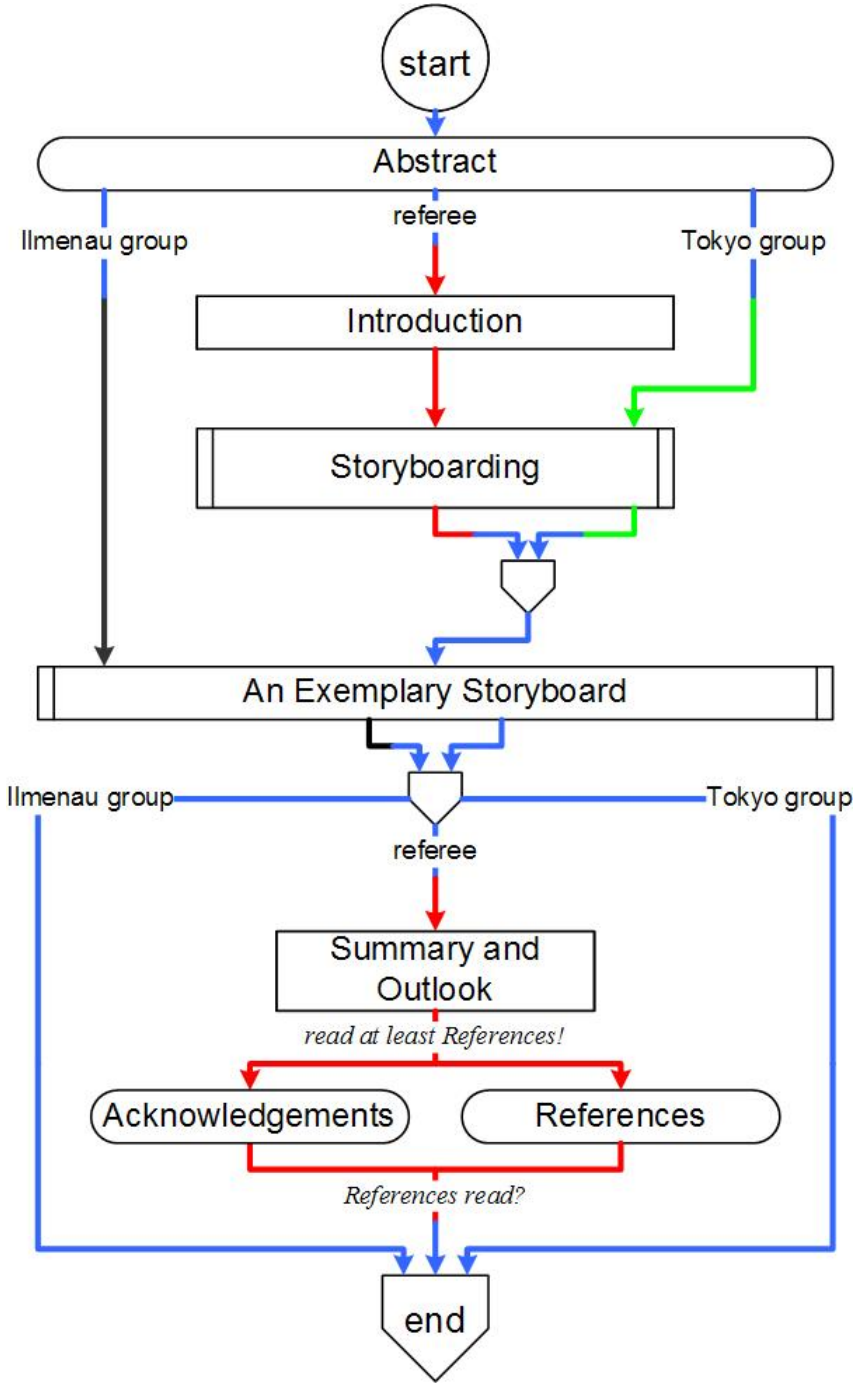
- ➢ **clarity** *by providing a formal high-level modeling approach, which enjoys*
- ➢ **simplicity** *and*
- ➢ **visual appearance**

3.2 A Storyboard – What is it?

- *A storyboard is a nested **hierarchy of** directed **graphs** with annotated nodes and annotated edges.*
- ***Nodes** are scenes or episodes.*
- ***Scenes** denote leaves of the nesting hierarchy.*
- ***Episodes** denote a sub-graph.*
- *Additionally, there is exactly one **Start**- and **End**- node to each (sub-) graph.*
- ***Edges** specify transitions between nodes. They may be single-color or bi-color.*
- *Nodes and edges have (pre-defined) **key attributes** and may have **free attributes**.*

Example:
A Storyboard of a recently submitted paper

- *Members of **Ilmenau group** may skip* **Introduction**, **Summary & Outlook**, *and* **Storyboarding** *because being familiar with it.*
- *Since the example application is new to them, they will study this example.*
- *Members of **Tokyo group** may also skip* **Introduction** *and* **Summary and Outlook** *for the same reason.*
- *They are interested in the recent refinements of the concept and thus, study the Storyboarding section.*
- *For being introduced to the storyboard of their study, they read the Exemplary Storyboard section.*
- ***Referees** may (hopefully) want to read all sections. They have to read the* **References** *and may be interested in the* **Acknowledgements**.



3.3 Knowledge Processing with storyboards

A storyboard can be traversed in different manners according to

1. users' interests, objectives, and desires,
2. didactic preferences (illustrations, examples, formal descriptions, …)
3. the sequence of nodes (and other storyboards) visited before (i.e. according to the educational history),
4. available resources (time, money, equipment to present material, …) and
5. other application driven circumstances.

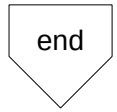
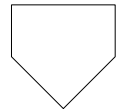
3.4 Interpretation of the elements

- **Scenes** non-decomposable learning activity implemented in any way, e.g.
  - presentation of a (media) document,
  - opening of a tool (URL, an e-learning system, ...)
  - informal activity description
- **Episodes** defined by their sub-graph
- **Graphs** interpreted by the paths, on which they can be traversed
- **Start Node** defines starting point of legal graph traversing
- **End Node** defines target point of a legal graph traversing
- **Edges** transitions between nodes, rules:

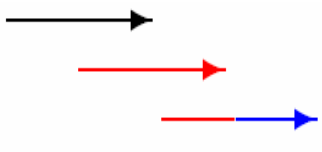
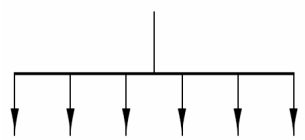
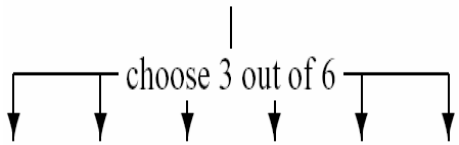
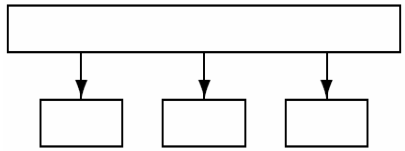
  (1) The outgoing edge must have the same color as the incoming edge by which the node was reached.

  (2) If there is a condition specified as the edge's key attribute, this condition has to be met for leaving the node by this edge.
- **Key attributes of nodes** specify application driven information for all nodes of the same type
- **Key attributes of edges** specify conditions, which have to be true for continuing traversing on this edge
- **Free attributes** specify whatever the storyboard author wants the user to know: didactic intentions, useful methods, necessary equipment, ...

Node types

	Scene	Episode	Start Node	End Node	Reference Node
Symbol					
Behavior on double click	▪ opening a document ▪ nothing, if just verbal activity description	opening the related sub-graph	jump to the **Start Node** of the related super-graph	jump to the **Reference Node** that successes it's associated **Episode Node** in the related super-graph	jump to the **End Node** of the sub-graph that is associated to the preceded **Episode Node**
Behavior on following a hyperlink	▪ opening a document ▪ visiting a website, if URL ▪ opening the mail tool, if email address	▪ opening a document ▪ visiting a website, if URL ▪ opening the mail tool, if email address	not meaningful		

Edge types

	Simple Edge	Fork	Fork with conditions	Alternatives
Symbol				
Inter-preta-tion	defines a unique successor node	defines several successor nodes, which are traversed independently in any sequence	defines several successor nodes, which are traversed independently in any sequence, but according to the specified condition	defines several successor nodes, out of which exacatly one has to be traversed

4 Example Storyboards so far

- University of Central Florida, FL, USA:

  Course EEL 4872 – Intelligent Systems

  - ..¥UCFcourseIS2006¥EEL4872 - Intelligent Systems¥EEL4872.VSD

- Tokyo Denki University, Kanto, Japan:

  Study of information Environment

  - ..¥Japan2006¥storyboard¥InformationEnvironmentAtTDU_2.VSD

- Technical University Ilmenau, Thuringia, Germany:

  Course on Inference Methods

  - ..¥..¥Lehre¥AktuelleVorlesungen¥IMStoryboard¥inferenz.VSD

5 Implemented formal Verification of Storyboards

5.1 Implemented Annotation Heritance

- In some applications it makes sense to inherit annotations from nodes (both scenes and episodes) to their related super-graph, e.g.
  - Material that are used to teach a particular lecture is also material to teach the complete subject the lecture is part of
- In other cases it makes sense to inherit the arithmetic sum of a key annotation of all nodes to the related super-graph, e.g.
  - An upper limit of the time needed to teach a subject can be estimated by the sum of its components (lectures)
  - A maximum cost of a university study can be estimated by the sum of the fees for all recommended subjects
- In other cases it makes sense to inherit the maximum value of a key annotation of all odes to the related super-graph
  - The educational difficulty (basic/easy, medium, advanced, very difficult) of a study needs to be communicated as the maximum value of all mandatory subjects

Thus, an appropriate inheritance method can be selected for each key annotation.

5.2 Implemented formal Verification of Storyboards

1. Episode-Hierarchy – Test
   - *Does every episode have exactly one related graph?*
   - *Does every (non-top) graph have exactly one related episode node in exactly one related super-graph?*
2. Reachability
   - *Does every traversing path terminate?*

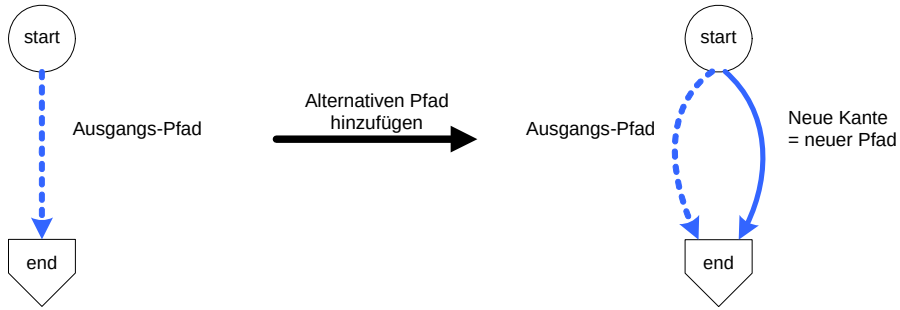
     In other words:
     *Is the **End** node reachable on every possible path in each (sub-) graph?*
   - *Is each node reachable from the **Start** node in each (sub-) graph?*
3. Completeness and non-contradictoriness of alternative outgoing edges (of the same beginning color)
4. Edge colors
   - *Is there a unique start color?*

     In other words:
     *Is there a unique (beginning) color of the **Start** node‘s outgoing edges?*
   - *Is there at least one outgoing edge with the same (beginning) color for each incoming edges‘ (finishing) colors?*

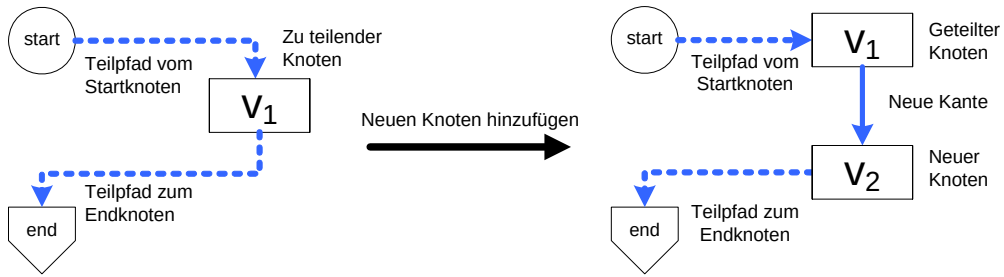
6 Current Work

6.1 Defining a set of operations to construct legal storyboards

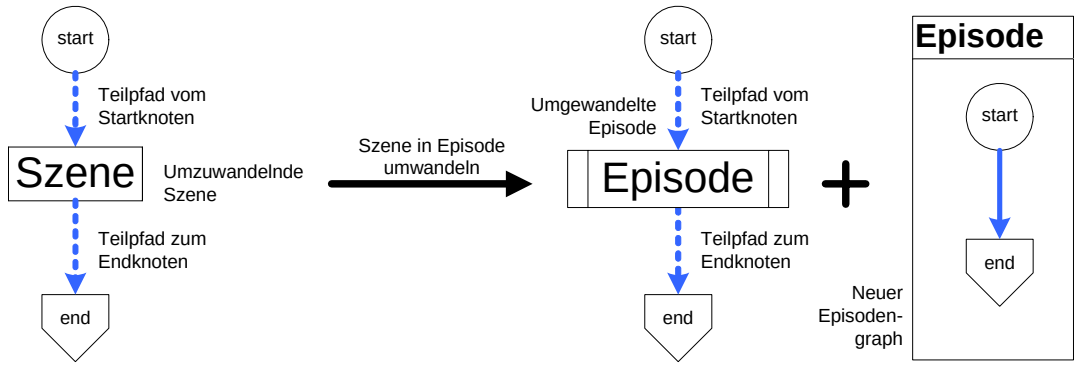
1. Adding Paths



2. Adding Nodes



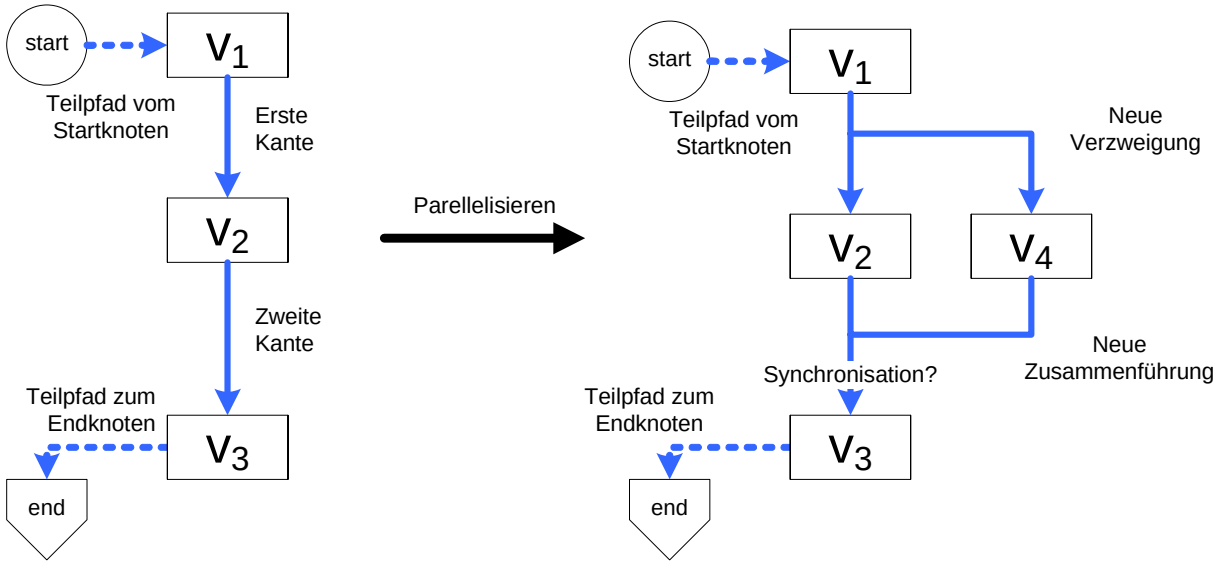
3. Turning Scenes to Episodes



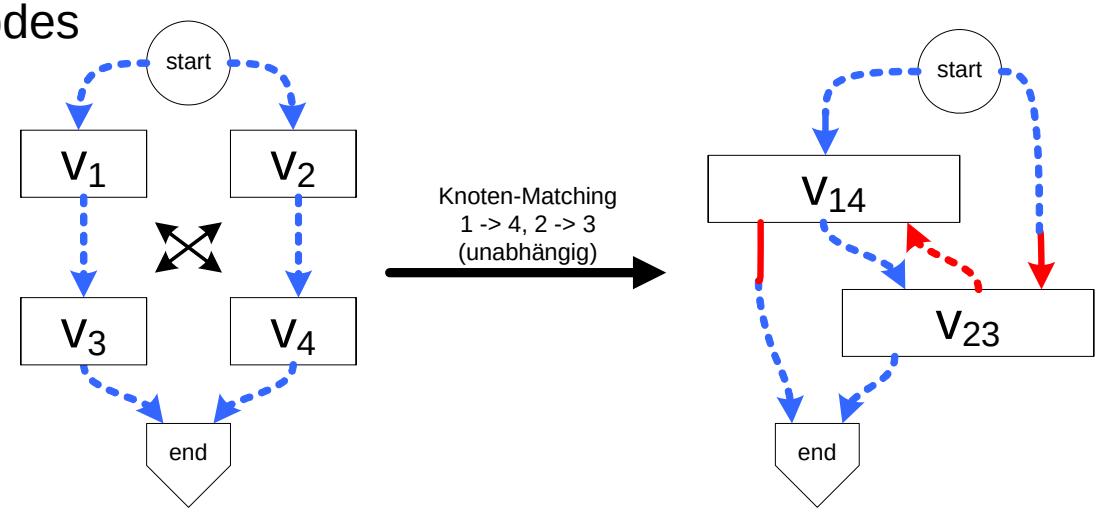
6 Current Work

6.1 Defining a set of operations to construct legal storyboards

4. Adding a Concurrent Path



5. Merging (equivalent) Nodes



6.2 Prediction of Success Chances of planned storyboard paths

Intended Application

- Evaluation of study plans (subject schedules) composed by students of Tokyo Denki University in advance of their study

Method

- Data Mining / Case Based Reasoning
  - Construction (and successive refinement) of a decision tree based on paths that have been gone by students, i.e. path with a known level of success
  - Application of the decision tree to estimate the success of a planned path

Approach

- Tree construction based on a “flatten” storyboard
- Tree forks at nodes with different successor node
- Tree leafs are the (known) success level (mark)
- Estimation by traversing tree until the path contains a “next node” different from all successors of the related tree node
- Weighted average mark of the sub-tree beginning at this node is the estimated success

6 Storyboards in General , Recent Results, and Outlook

1. Storyboarding is a way of managing didactic knowledge for organizing learning experience.
   - *The proposed concept leads beyond the limits of software engineering.*
   - *All didactic forms may be included*
     - *(1) collaborative work,*
     - *(2) competitive work,*
     - *(3) classical learning forms, even*
     - *(4) "playful learning" by involving game situations*
2. Three examples (at a US-, a Japanese -, and a German University) indicate that the concept is very general and "many purpose".
3. Because of clarity and simplicity, everybody can become a storyboard author.
   - *No Software technological Knowledge is needed, no specialized (expensive) tool is needed.*
4. Didactic design becomes explicit and subject to evaluation & quality assurance
   - ***Structure tests*** *for verification can be performed*
   - ***Validation****: in a case-based manner by practical use*
   - ***Refinement****: path analyses of successful / less successful paths*
   - ***Learning Didactic Knowledge****: inductively infer successful patterns*
   - ***Supporting Didactic design****: provide a set of operations and a tool that ensures legal and valid storyboards*