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# E-Learning: State of the Art sowie neue Entwicklungen mit adaptiven Lernplattformen

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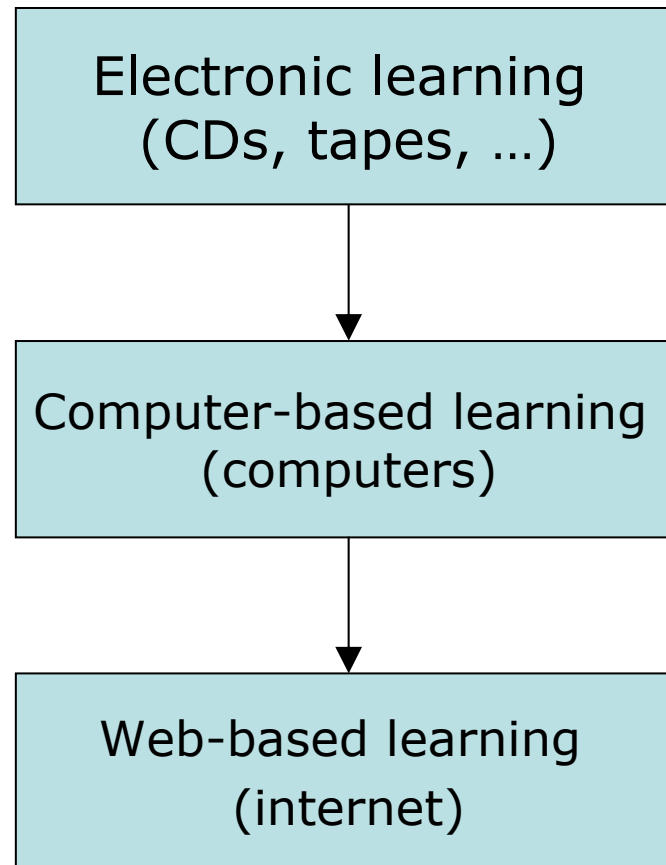
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- What is e-learning?
- New generations and forms of learning
  - Mobile learning
  - Informal learning
  - Game-based learning
  - Adaptive/Personalized Learning
- Adaptivity in Learning Management Systems focussing on Learning Styles
  - How can learning styles be identified in learning management systems
  - How can cognitive abilities help in this detection process?
  - How can adaptivity with respect to learning styles be presented in LMS?
- Future Research Directions

# What is e-Learning?

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# What is e-Learning?

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- e-learning + e-teaching = e-education
- technology enhanced learning
- blended learning

## Learning Management Systems

- Created for supporting teachers/course developers
- Provide a great variety of features
  - Content
  - Multimedia files
  - Quizzes
  - Forums
  - Chat
  - Wiki
  - Blogs
  - ...
- Support of
  - Administration of courses
  - Marking
  - Tracking mechanism
  - ...

## ■ Mobile learning

- Using mobile devices (PDAs, mobile phones, ...) for learning at different places
- Taking advantages of learning opportunities offered by mobile devices
- For example,
  - Learning about plants in the nature
  - Learning a foreign language by walking around in the respective country
  - Learning in a museum

## ■ Informal learning

- Learning without the intention of learning
- Occurs in everyday life and may not even be recognized as learning
- For example,
  - Learning to speak
  - Unplanned discussions
  - Arising interest for something

## ■ Game-base learning

- Learning while playing → informal learning
- Basic idea: combine learning and playing games
- For example,
  - Games including some questions
  - Games which play in a specific environment (e.g., 1000 years ago)
  - Role-playing games
  - Management games
  - Strategical games



- Adaptive/Personalized learning
  - Learning is adapted to each individual person
  - Basic idea: learning systems provide learners with courses that fits to their individual needs
  - For example,
    - Systems which adapt to the learners`
      - Prior knowledge
      - Goals
      - Motivation
      - Cognitive abilities
      - Learning styles

- Adaptive systems aim at providing adaptivity
  - AHA!
  - TANGOW
  - INSPIRE
  - MASPLANG
  - ...
  
- Limitations
  - are either developed for specific content (e.g. accounting) or for specific features (e.g. adaptive quizzes)
  - content cannot be reused
  - are not often used

- Learning Management Systems (e.g., Moodle, Blackboard, WebCT, ...) are developed to support authors/teachers to create courses
  - provide a lot of different features
  - domain-independent
  - content can be reused in other LMS
  - are often used in e-learning
  - provide only little or in most cases no adaptivity

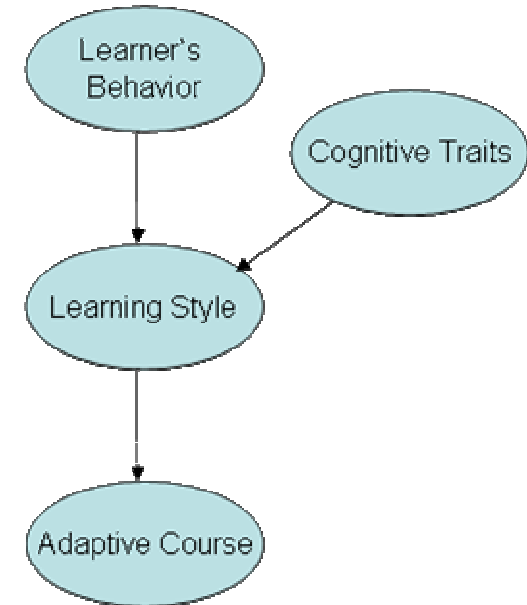
## ■ Aim of my research

- Combining the advantages of LMSs with those of adaptive systems
- Extend LMSs with adaptivity
- Incorporate learning styles in LMSs

## ■ General aims

- Developing concepts for LMSs in general
- Implementing and evaluating these concepts by the use of a prototype (Moodle)
- Teachers should have as little as possible additional effort

- How to identify learning styles?
- How to improve the detection process of learning styles by the use of additional sources?
- How to provide adaptivity based on learning styles in LMS?



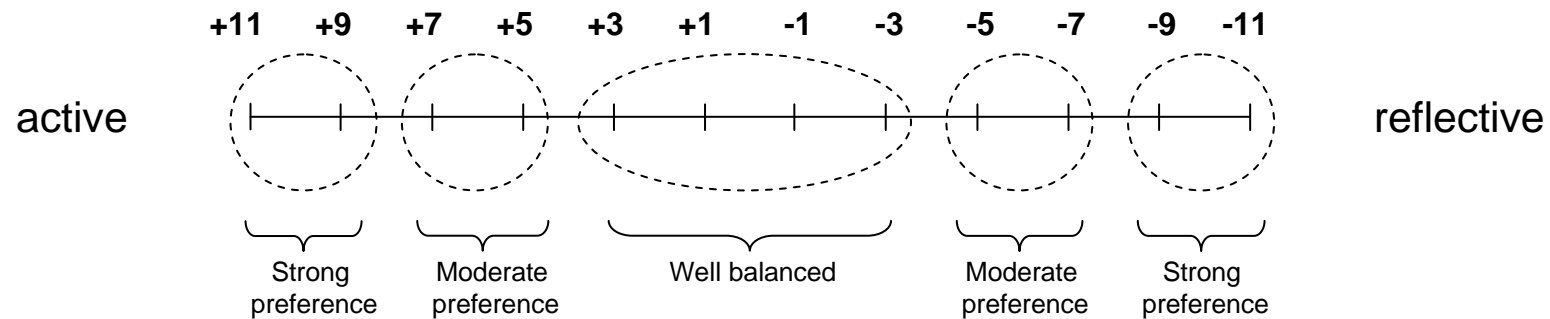
# Felder-Silverman Learning Style Model (1/2)

- Each learner has a preference on each of the dimensions
- Dimensions:
  - Active – Reflective  
learning by doing – learning by thinking things through  
group work – work alone
  - Sensing – Intuitive  
concrete material – abstract material  
more practical – more innovative and creative  
patient / not patient with details  
standard procedures – challenges
  - Visual – Verbal  
learning from pictures – learning from words
  - Sequential – Global  
learn in linear steps – learn in large leaps  
good in using partial knowledge – need „big picture“



# Felder-Silverman Learning Style Model (2/2)

- Scales of the dimensions:



→ Strong preference but no support → problems

- Differences to other learning style models:

- Combines major learning style models (Kolb, Pask, Myers-Briggs Type Indicator)
- New way of combining and describing learning styles
- Describes learning style in more detail (Types <-> Scale)
- Represents also balanced preferences
- Describes tendencies

# How to identify learning styles?



# How to identify learning styles?

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- Collaborative student modelling
  - “Index of Learning Styles” (ILS) questionnaire
    - 44 questions (11 for each dimension)
    - Online available
  - Problems with questionnaires
    - Reliability & validity of the instrument
    - Motivate students to fill it out
    - Non-intentional influences
    - Can be done only once

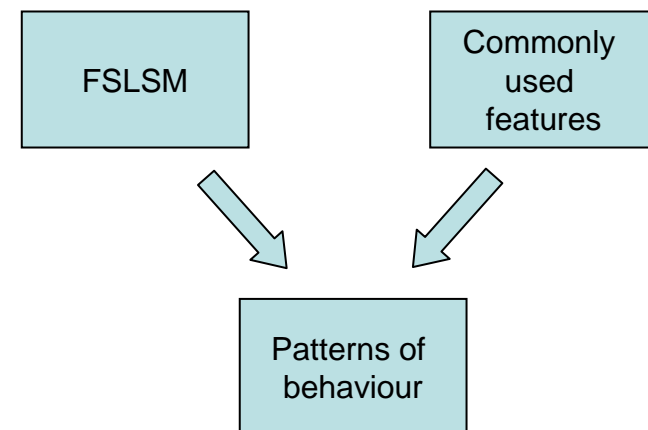
# How to identify learning styles?

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- Automatic student modelling
  - What are students really doing in an online course?
  - Infer their learning styles from their behaviour
  - Advantages:
    - Students have no additional effort
    - Can be updated frequently → higher tolerance
  - Problem/Challenge:
    - Get enough reliable information to build a robust student model

# Determining Relevant Behaviour

- Felder and Silverman describe how learners with specific preferences act in learning situations
- Mapped the behaviour to online-learning
- Only commonly used features are considered:
  - Content objects
  - Outlines
  - Examples
  - Self-assessment tests
  - Exercises
  - Discussion Forum



# Determining Relevant Behaviour

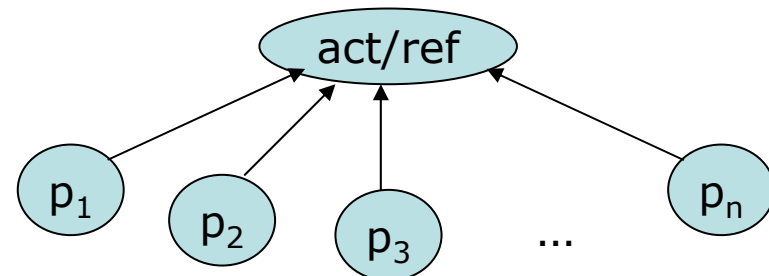
Active/Reflective	Sensing/Intuitive	Visual/Verbal	Sequential/Global
selfass_visit (+)	ques_detail (+)	forum_visit (-)	ques_detail (+)
exercise_visit (+)	ques_facts (+)	forum_stay (-)	ques_overview (-)
exercise_stay (+)	ques_concepts (-)	forum_post (-)	ques_interpret (-)
example_stay (-)	selfass_visit (+)	ques_graphics (+)	ques_develop (-)
content_visit (-)	selfass_result_duration (+)	ques_text (-)	outline_visit (-)
content_stay (-)	selfass_duration (+)	content_visit (-)	outline_stay (-)
outline_stay (-)	exercise_visit (+)		navigation_skip (-)
selfass_duration (-)	ques_rev_later (+)		overview_visit (-)
selfass_result_duration (-)	ques_develop (-)		overview_stay (-)
selfass_twice_wrong (+)	example_visit (+)		
forum_visit (-)	example_stay (+)		
forum_post (+)	content_visit (-)		
	content_stay (-)		

## ■ Data-driven approach

- Using Bayesian Networks in order to build a model to identify learning styles
- Train the model with data about behaviour and learning styles

→ can represents dependencies in the model more accurate

→ very much dependent on data



## ■ Literature-based approach

- Building a model based on literature
- Based on the idea that behaviour of learners provide hints on their learning styles.
- Using indications from data and a simple rule-based approach to identify learning styles

→ is very general since it is based on literature

→ dependencies in the model might be less accurate

- Study with 75 students
  - Let them fill out the ILS questionnaire
  - Tracked their behaviour in an online course
- Aim was to identify learning styles on a 3-item scale (e.g., active, balanced, reflective)
- Investigated the efficiency of the data-driven approach and the literature-based approach
- Using a measure of precision

$$\text{Precision} = \frac{\sum_{i=1}^n \text{Sim}(LS_{\text{predicted}}, LS_{\text{ILS}})}{n}$$

# Results

Correctly detected learning styles:

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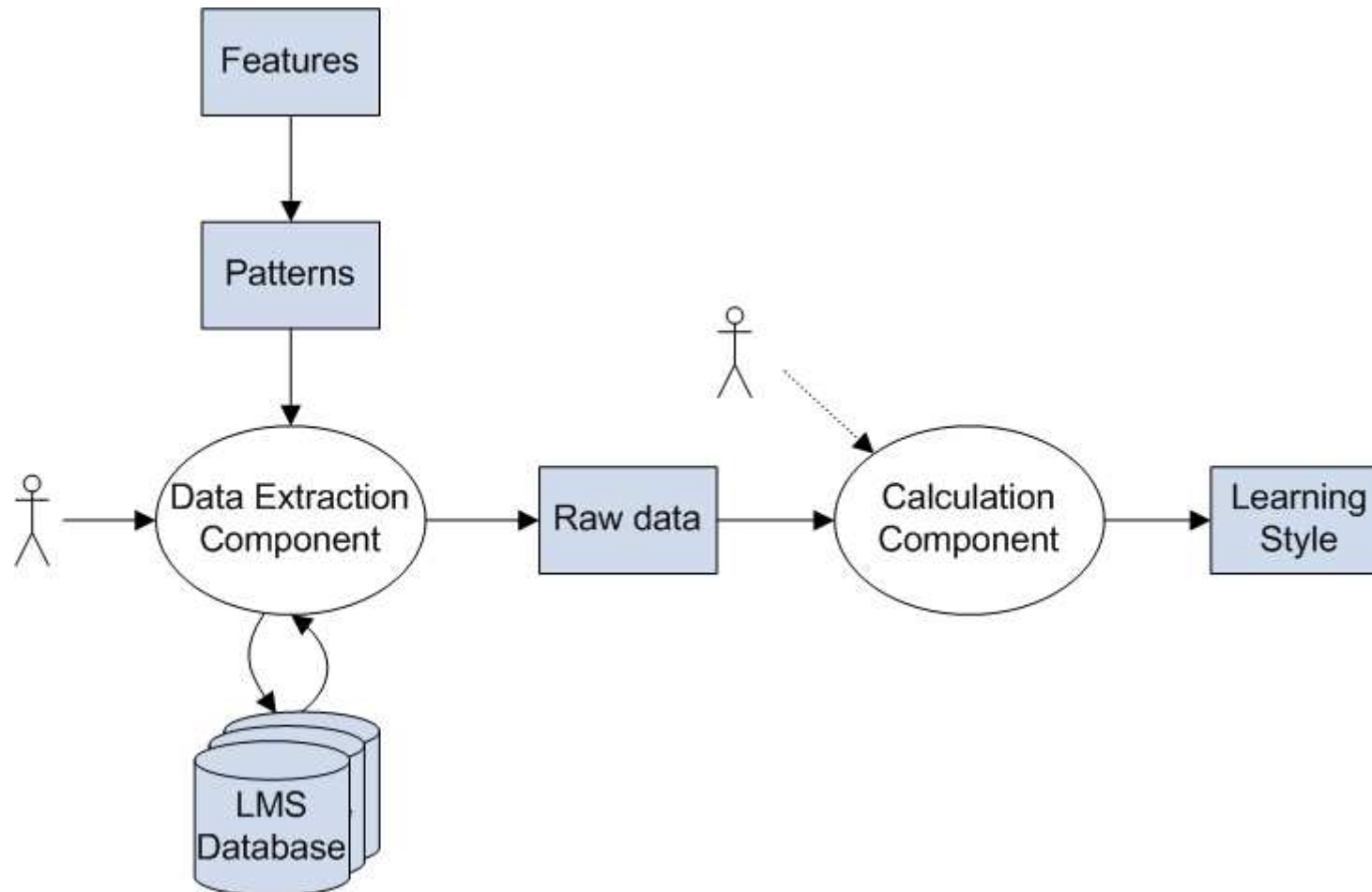
	act/ref	sen/int	vis/ver	seq/glo
data-driven	62.50	65.00	68.75	66.25
literature-based	<b>79.33</b>	<b>77.33</b>	<b>76.67</b>	<b>73.33</b>

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- DeLeS = **D**etecting **L**earning **S**tyles
- Basic concept
  - Define relevant patterns of behaviour
  - Extract data about patterns from the LMS database
  - Use literature-based approach to calculate learning styles based on the gathered data
- Requirements
  - Applicable for LMS in general
    - Usable for different database schemata
    - Deal with missing data since maybe not all information can be tracked by each LMS

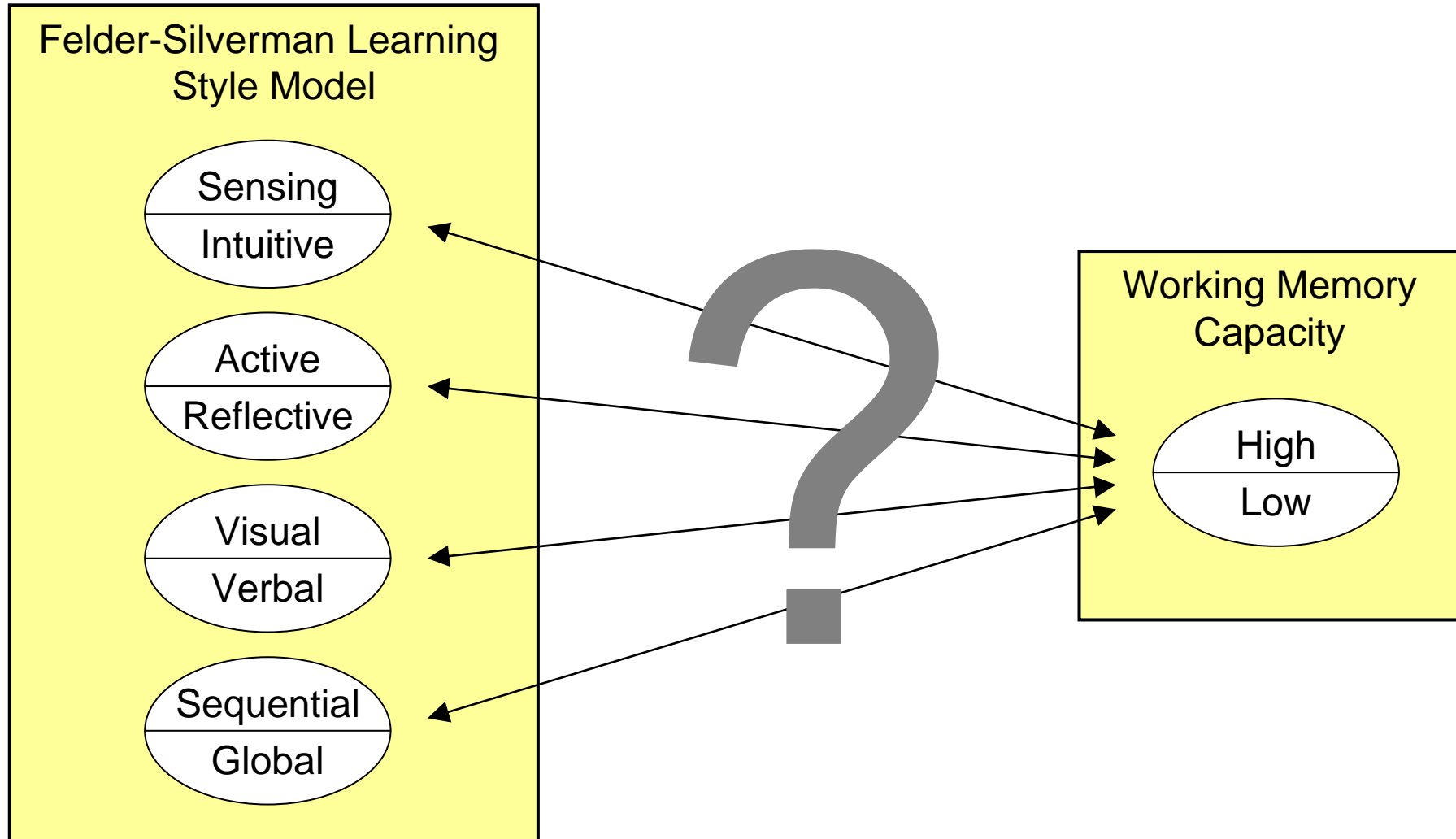
# Tool Architecture



# Improving the detection of learning styles by using information from cognitive traits

- The aim is to use additional source in order to get more information to identify learning style more accurately
- Exemplarily, we investigated the relationship between learning styles and working memory capacity

# Relationship between FSLSM and WMC

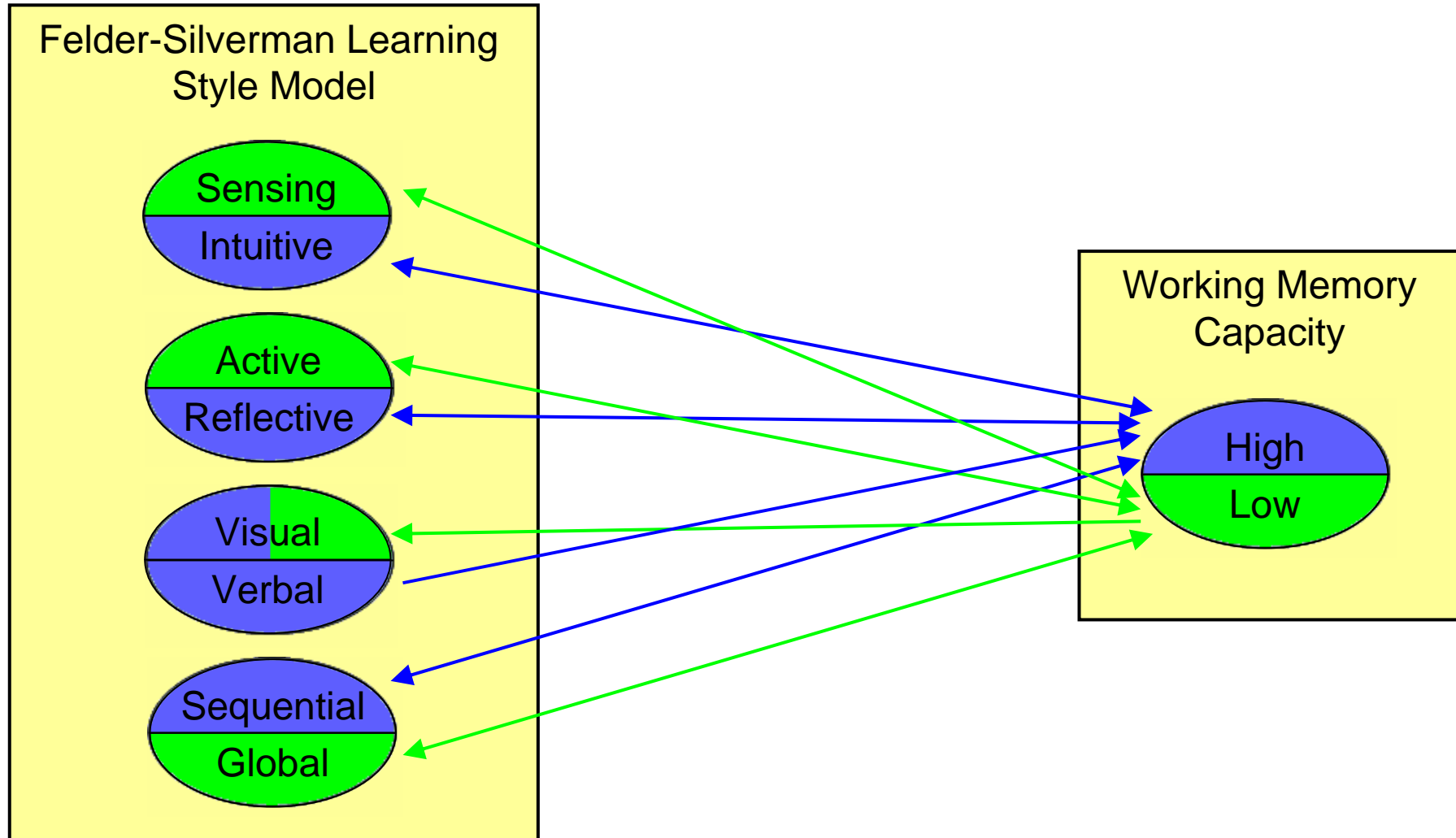


# Literature Research

Felder-Silverman Learning Style Dimensions	High WMC	Low WMC
	<b>Reflective</b>	<b>Active</b>
	Beacham, Szumko, and Alty (2003) Hadwin, Kirby, and Woodhouse (1999) Kolb (1984) Summervill (1999) Witkin et al. (1977)	
	<b>Intuitive</b>	<b>Sensing</b>
Bahar and Hansell (2000) Davis (1991) Ford and Chen (2000) Hudson (1966) Kinshuk and Lin (2005) Scandura (1973) Witkin et al. (1977)		
<b>Verbal or Visual</b>	<b>Visual</b>	
Beacham, Szumko, and Alty (2003) Simmons and Singleton (2000) Wey and Waugh (1993)		
<b>Sequential</b>	<b>Global</b>	
Beacham, Szumko, and Alty (2003) Ford and Chen (2000) Huai (2000) Liu and Reed (1994) Mortimore (2003) Witkin et al. (1977)		

Cognitive Styles	High WMC	Low WMC
	Field-independent	Field-dependent
	Al-Naeme (1991) Bahar and Hansell (2000) El-Banna (1987) Pascual-Leone (1970)	
Divergent		Convergent
Bahar and Hansell (2000)		
Serial		Holistic
Huai (2000)		

# Relationship between FSLSM and WMC



# Verifying the relationship

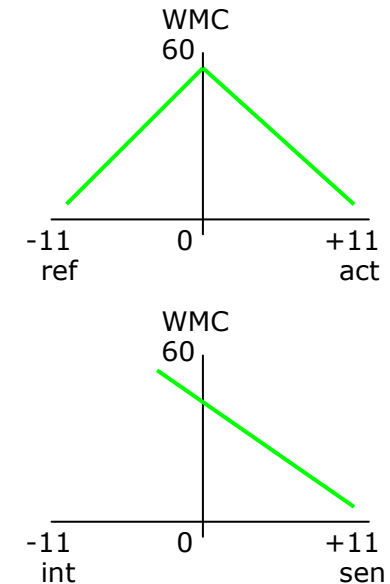
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- Participants
  - 225 students from Austria
- Detecting learning styles
  - ILS questionnaire
- Detecting working memory capacity
  - WebOSpan Task



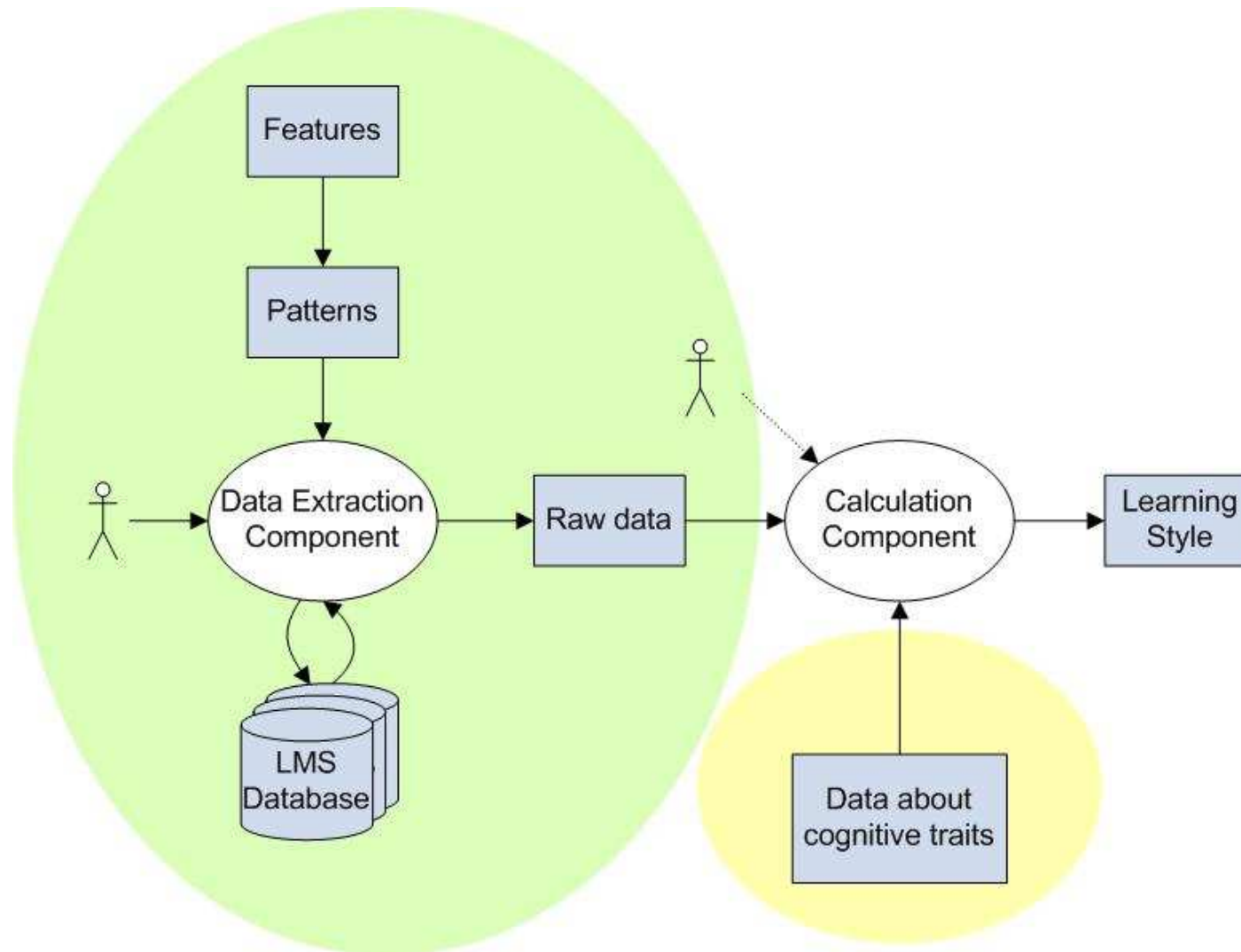
# Results

- Active/reflective:
  - Low WMC  $\leftrightarrow$  strong active preference
  - Low WMC  $\leftrightarrow$  strong reflective preference
  - High WMC  $\leftrightarrow$  balanced learning preference
- Sensing/intuitive:
  - Low WMC  $\leftrightarrow$  sensing learning preference
  - High WMC  $\leftrightarrow$  balanced learning preference
- Visual/verbal:
  - Low WMC  $\rightarrow$  visual learning preference
  - Verbal learning preference  $\rightarrow$  high WMC
- Sequential/Global:
  - No relationship found



→ Identified relationships can be included in the detection process of learning styles and cognitive traits

# Using the information in DeLeS



# How to provide adaptivity?

# How to provide adaptivity?

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- Develop a concept which enables LMS to automatically generate adaptive courses
- Incorporates only common kinds of learning objects
  - Content
  - Outlines
  - Conclusions
  - Examples
  - Self-assessment tests
  - Exercises
- Requirements for teachers
  - Provide learning objects
  - Annotate learning objects (distinguish between the objects)

- Number of examples
- Number of exercises
- Sequence of examples (before or after content)
- Sequence of exercises (before or after content)
- Sequence of self-assessments (before or after content)
- Sequence of outlines (only once before content or between content)
- Sequence of conclusion (after content or at the end of the chapter)

## ■ Active learners

- Self-assessments before and after content
- High number of exercises
- Low number of examples
- Outline only at the begin of content
- Conclusions at the end of the chapter

## ■ Reflective learners

- Outlines between content
- Conclusion after content
- Avoid self-assessments before content
- Examples after content
- Exercises after content
- Low number of exercises

- Sensing learners
  - High number of examples
  - Examples before content
  - Self-assessment after content
  - High number of exercises
  - Exercises after content
- Intuitive learners
  - Self-assessment before content
  - Exercises before content
  - Low number of exercises
  - Low number of examples
  - Examples after content
  - Outlines only at the begin of content

- Sequential learners
  - Outlines only at the begin of content
  - Examples after content
  - Self-assessment after content
  - Exercises after content
- Global learners
  - Outlines between content
  - Conclusion after content
  - High number of examples
  - Avoid self-assessment before content
  - Avoid examples before content
  - Avoid exercises before content



- Active/Reflective = +11 → strong active style
- Sensing/Intuitive = -11 → strong intuitive style
- Sequential/Global = -11 → strong global style
- Number of Exercises
  - Active → high number
  - Intuitive → low number
  - Global → no preference→ Moderate number of exercises

- Implemented add-on for Moodle (Version 1.6.3)
- Evaluated with 437 students participating in a course about object-oriented modelling
- Randomly assigned to 3 groups:
  - Courses that fit to the students' learning styles (matched group)
  - Courses that do not fit to the students' learning styles (mismatched group)
  - Standard course which includes all learning objects (standard group)

## ■ Procedure

- Students filled out a learning style questionnaire
- Adaptive course is automatically generated and presented
- Students were nevertheless able to access all learning objects and take a different learning path

# Evaluation of the Concept

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## ■ Results:

- Average score on assignments & score on final exam
  - no significant difference
- Time spent on learning activities
  - Standard (5h 34 min) > Matched (3h 47min)
  - Mismatched (5h 33min) > Matched (3h 47min)
- Number of logins
  - Standard (32 logins) > Matched (28 logins)
- Number of visited learning activities
  - no significant difference
- Number of requests for additional LOs
  - Mismatched (8.30%) > Matched (6.59%)

→ Students from the matched group spent significant less time in the course but achieved in average equal grades

→ Demonstrates positive effect of adaptivity

# Future Research Directions

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- Generalising the adaptive mechanism
- Combine Automatic Student Modelling with Providing Adaptivity
- Dynamic Automatic Student Modelling
- Supporting students in learning with their weak learning style preferences

# Questions



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