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Adaptivity in Learning Management Systems focussing on Learning Styles

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Why shall we consider learning styles in LMS?

- Learning Management Systems (LMS) are commonly and successfully used in e-education but they provide the same course for all learners
- Learners have different needs
- Adaptivity increases the learning progress, leads to better performance, and makes learning easier

Adaptive Systems

- Adaptive systems aim at providing adaptivity
  - AHA!
  - TANGOW
  - INSPIRE
  - ...
- 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

Adaptive Systems and LMS

- 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 and successfully used in e-education
  - provide only little or in most cases no adaptivity

How to incorporate learning style in LMS?

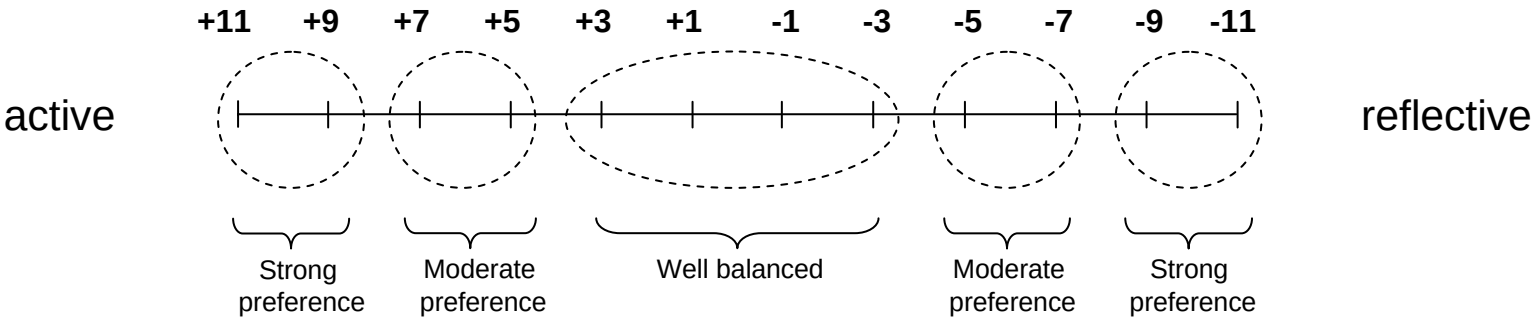
- Focus on adaptivity based on learning styles
- How to incorporate learning styles in LMS?
  - How to identify learning styles automatically based on the behaviour of learners?
  - How to improve the detection process of learning styles by the use of additional sources?
  - How to provide adaptivity based on learning styles in LMS?
- General aims
  - Developing and evaluating a concept for LMS in general that enables the systems to incorproate learning styles
  - Teachers should have as little as possible additional effort

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“
    serial – holistic

Felder-Silverman Learning Style Model (2/2)

- Scales of the dimensions:



→ Strong preference but no support → problems

- Differences to other learning style models:
  - describes learning style in more detail
  - represents also balanced preferences
  - describes tendencies

How to identify learning styles?

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

How to identify learning styles?

- 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
      → certain amount of data about the behaviour
      → use information related to learning styles as additional source

DeLeS – A tool to identify learning style in LMS

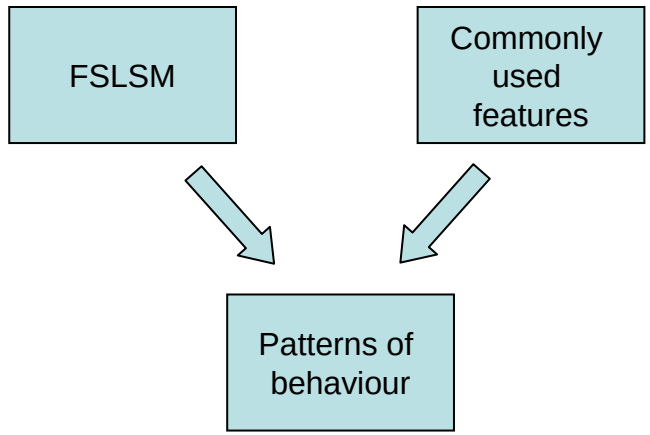
- DeLeS = **De**tecting **Le**arning **S**tyles
- Basic concept
  - Define relevant patterns of behaviour
  - Extract data about patterns from the LMS database
  - Calculate learning styles based on the gathered data
- Requirements
  - Applicable for LMS in general

    → Usable for different database schemata

    → Deal with missing data since maybe not all information can be tracked by each LMS

Patterns of 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
  - Tests (self-assessment and marked)
  - Exercises
  - Communication tools (forum, chat)



Patterns of Behaviour

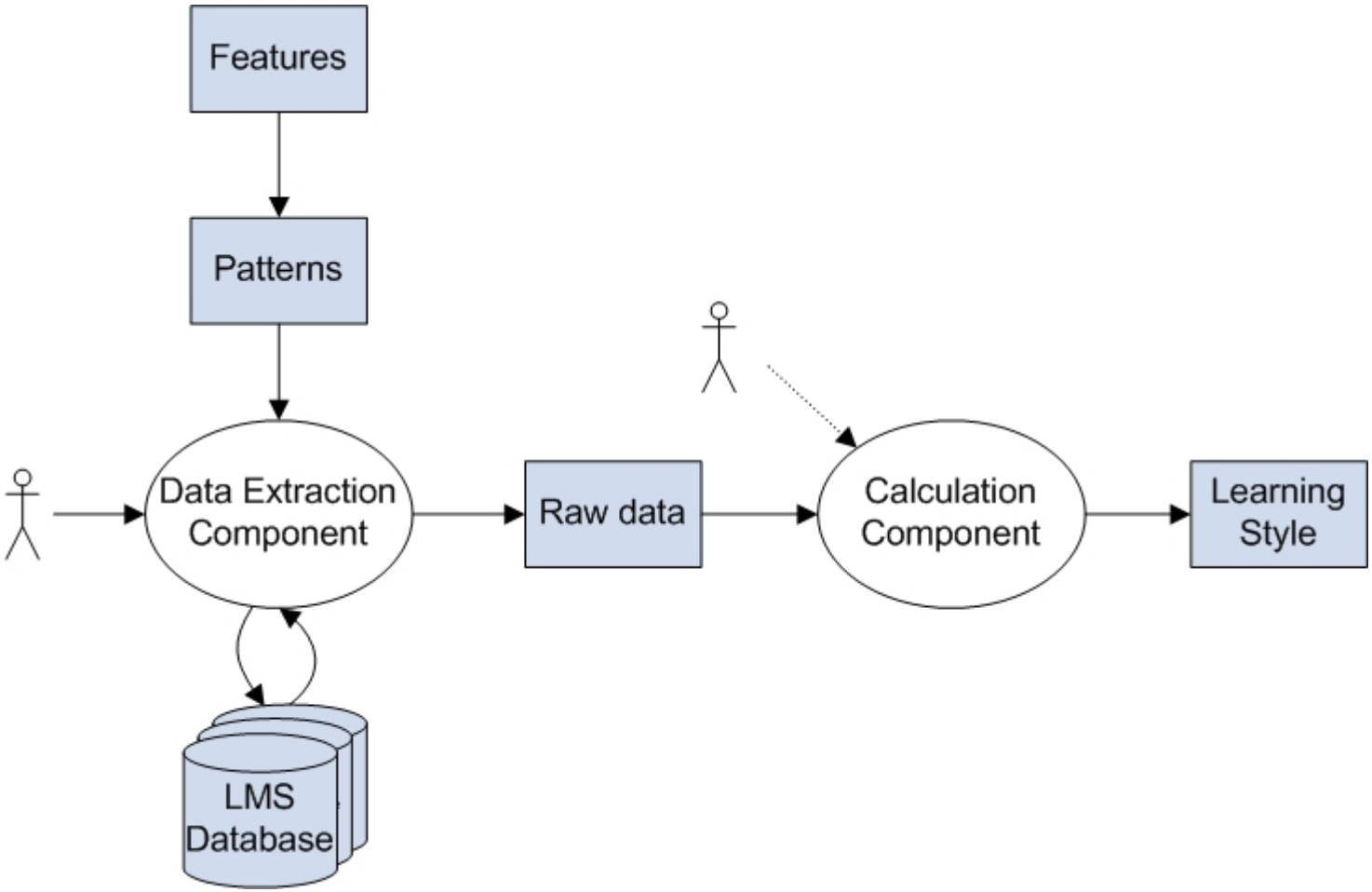
Active/Reflective
Visits of forum (act)
Postings in forum (act)
Visits of chat (act)
Postings in chat (act)
Visits of exercise (act)
Time spent on exercises (act)
Time spent on examples (ref)
Time spent on content objects (ref)

Sequential/Global
Correct answers: detail/overview (seq)
Performance of marked tests (seq)
Performance of self-assessment tests (seq)
Visits of outline (glo)
Time spent on outline (glo)
Skips learning objects (glo)
Visits of course overview page (glo)
Time spent on course overview page (glo)

Sensing/Intuitive
Correct answers: facts/concepts (sen)
Revisions of marked tests (sen)
Revisions of self-assessment tests (sen)
Duration of marked tests (sen)
Duration of self-assessment tests (sen)
Visits of exercises (int)
Time spent on exercises (int)
Visits of self-assessment tests (sen)
Visits of examples (sen)
Time spent on examples (sen)

Visual/Verbal
Visits of forum (ver)
Postings in forum (ver)
Visits of chat (ver)
Postings in chat (ver)
Time spent on graphics (vis)
Correct answers: graphics (vis)

Tool Architecture



Evaluation of DeLeS

- Extended Moodle to track all required data
  - Additional meta-data for distinguishing between certain kinds of learning objects (e.g. content/example/outline or self-assessment/marked_test/exercise)
  - Additional meta-data to specify certain learning objects in more detail (e.g. kind of questions, inclusion of graphics)
  - Extended tracking features regarding revisions on tests
- Case studies
  - 75 students (Object-oriented modelling course)
  - 43 students (Web-Engineering course)
- Ongoing work
  - Using Bayesian Networks in order to identify dependencies between patterns of behaviour and learning styles
  - Combining the results with the patterns derived from literature
  - Evaluating the detection process of learning styles by comparing the results from DeLeS with results from the ILS questionnaire

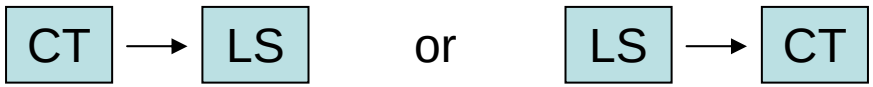
Improving the detection of learning styles

- Investigations about learning styles and cognitive abilities
  - Abilities to perform any of the functions involved in cognition whereby cognition can be defined as the mental process of knowing, including aspects such as awareness, perception, reasoning, and judgment.
  - Cognitive abilities are more or less stable over time
  - Important abilities for learning
    - Working memory capacity
    - Inductive reasoning ability
    - Information processing speed
    - Associative learning skills

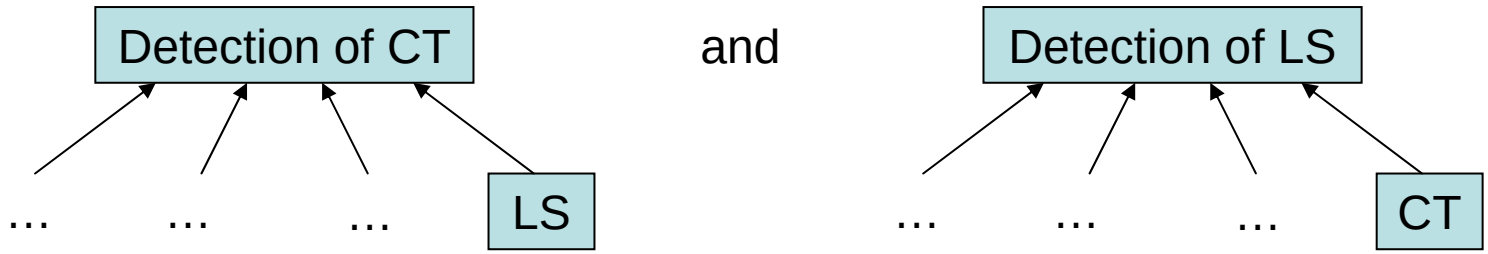
Relationship between Cognitive Traits and Learning Styles

Why shall we relate cognitive traits and learning styles?

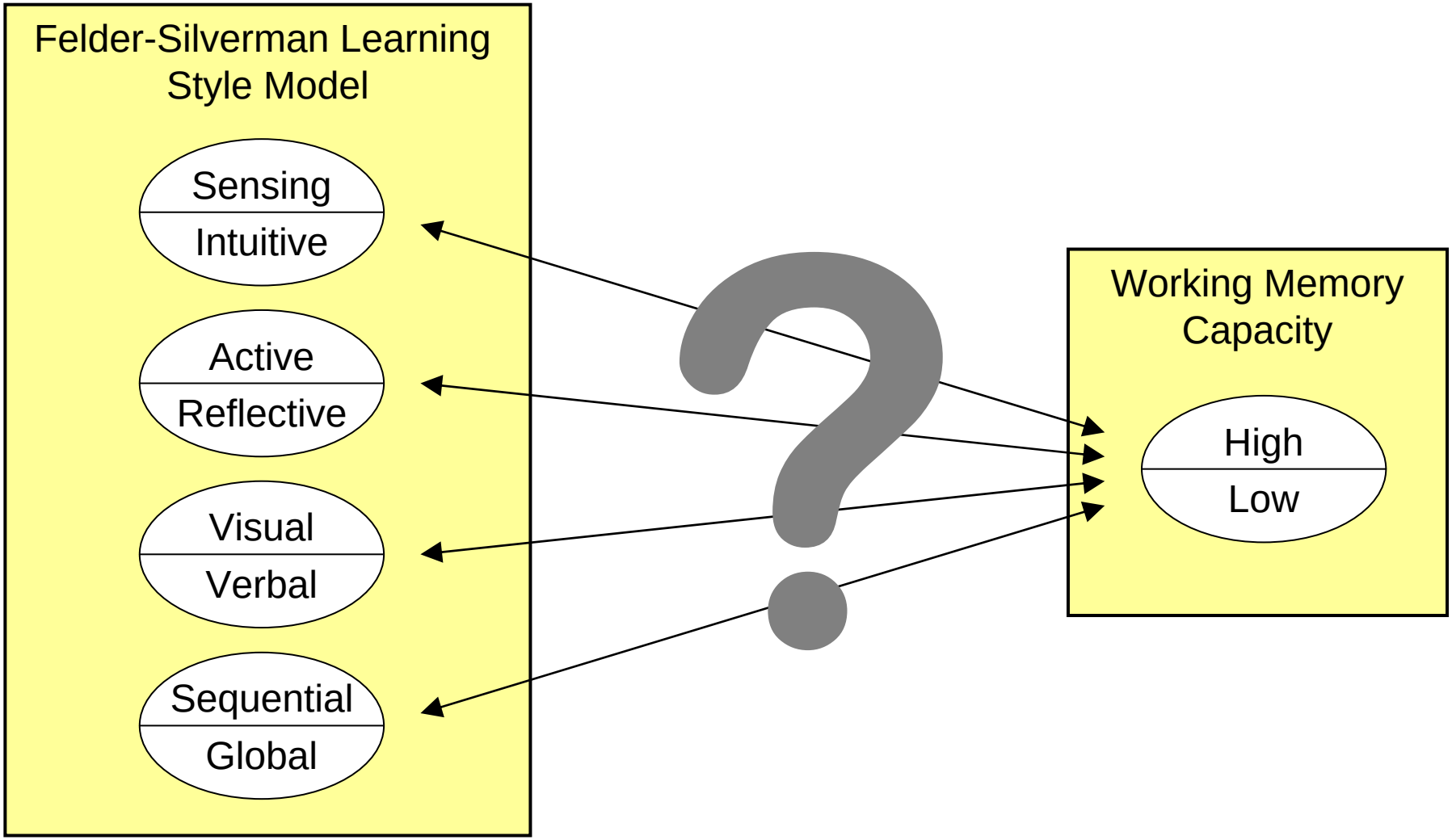
- Case 1: Only one kind of information (CT and LS) is considered
  → Get some hints about the other one



- Case 2: Both kinds of information are considered
  → The information about the one can be included in the identification process of the other and vice versa
  → The student model becomes more reliable



Relationship between FSLSM and WMC

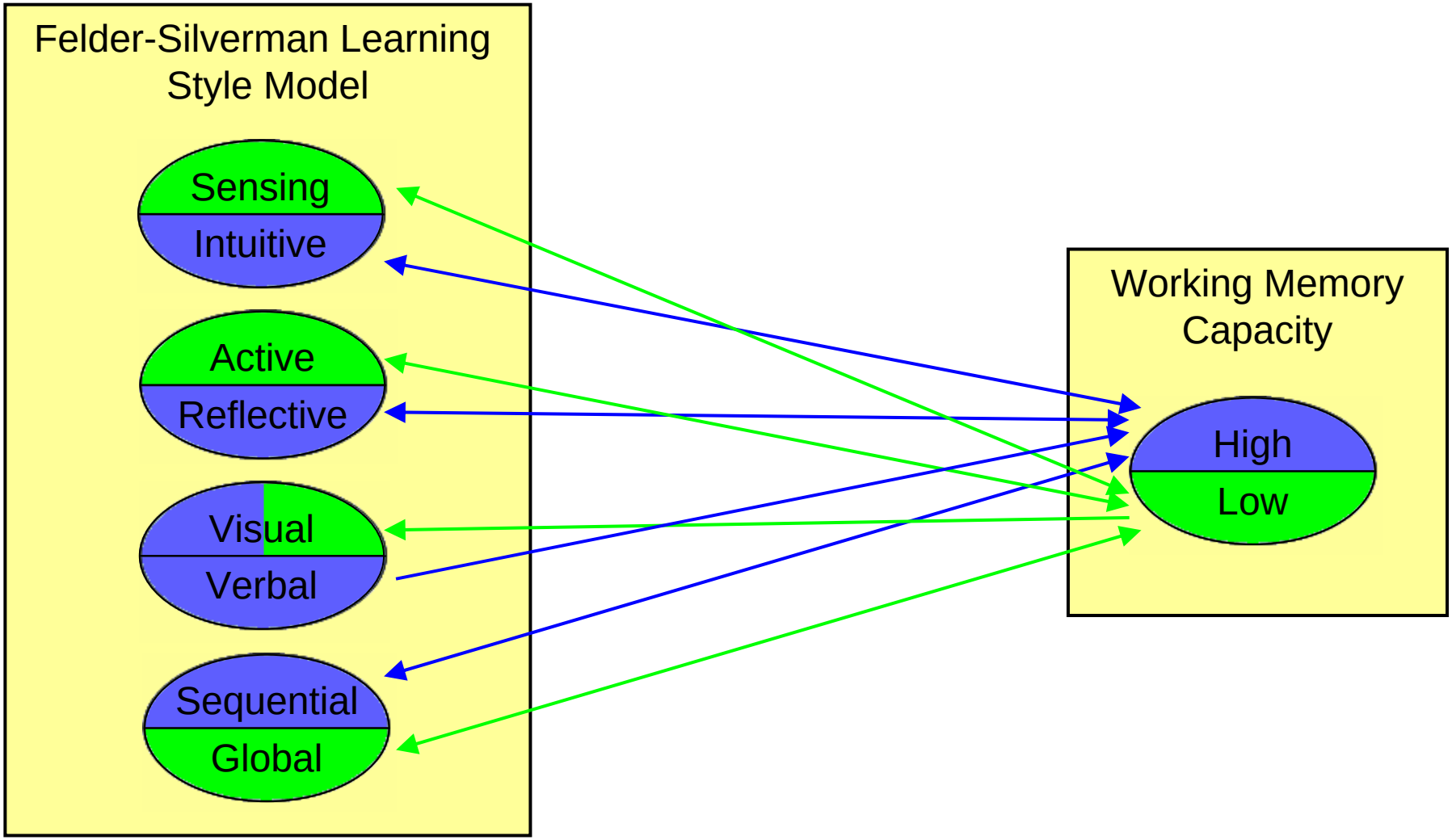


Literature Research

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

	High WMC	Low WMC
Cognitive Styles	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

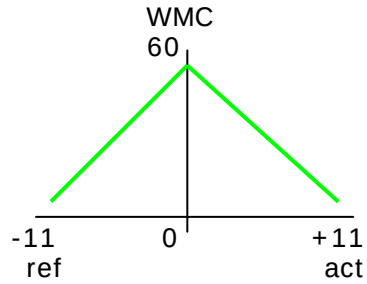


Verifying the relationship

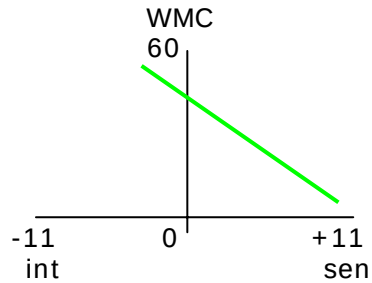
- Participants
  - 225 students from Austria
- Detecting learning style
  - ILS questionnaire
- Detecting working memory capacity
  - WebOSpan Task

Results

- Active/reflective:
  - Low WMC <-> strong active preference
  - Low WMC <-> strong reflective preference
  - High WMC <-> balanced learning preference



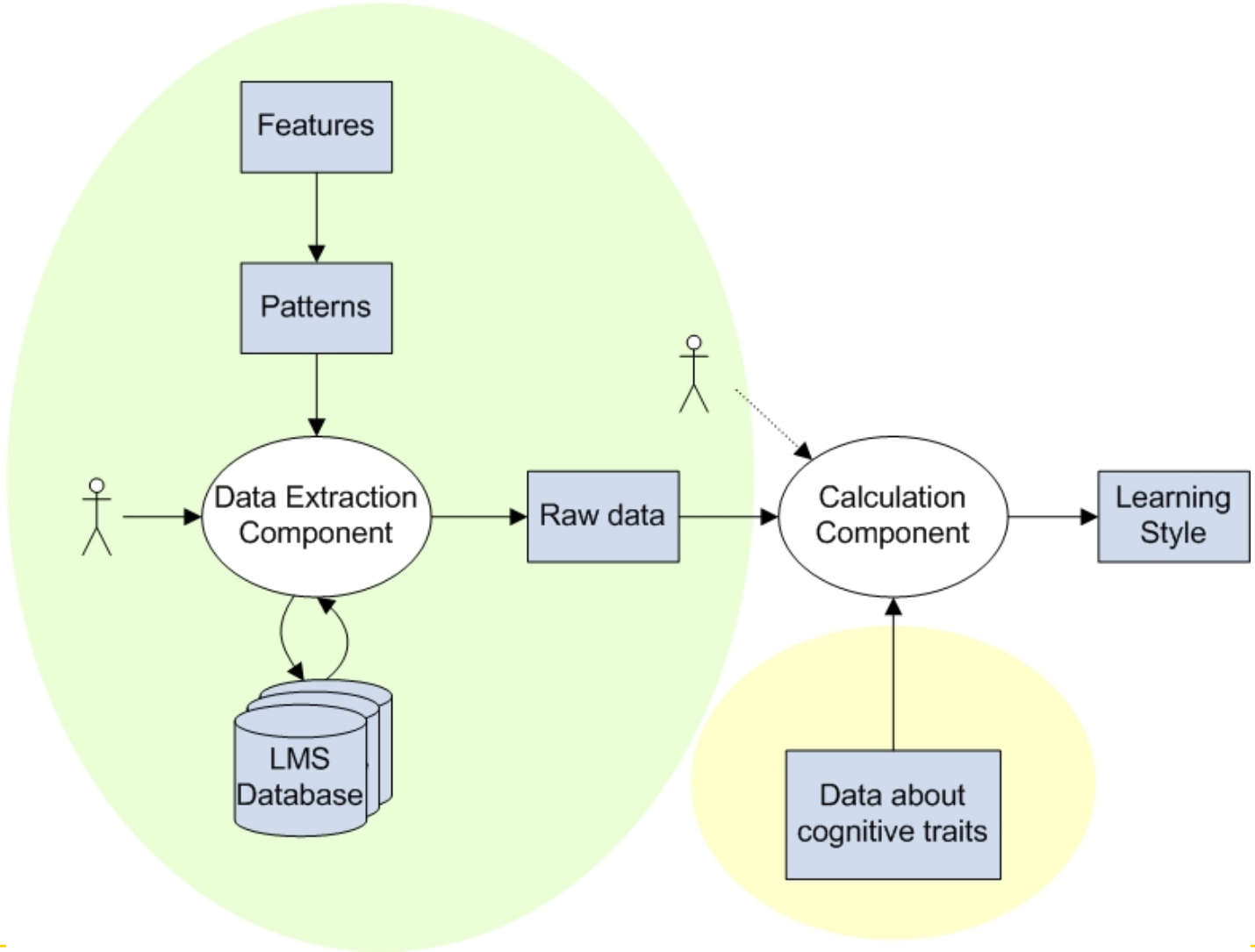
- Sensing/intuitive:
  - Low WMC <-> sensing learning preference
  - High WMC <-> balanced learning preference



- Visual/verbal:
  - Low WMC -> visual learning preference
  - Verbal learning preference -> 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?

- 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)

Structure of a course

Chapter 1:

- **Examples**
- **Self-assessment**
- **Exercises**
- **Outline**
- **Content with / without outlines between subchapters**
- **Conclusion**
- **Examples**
- **Self-assessment**
- **Exercises**
- **Conclusion**

Chapter 2:

- **...**

Adaptation features

- 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)
- Number of examples
- Number of exercises

Adaptations for active/reflective learners

- 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

Adaptations for sensing/intuitive learners

- 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

Adaptations for sequential/global learners

- 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

Ambiguous Learning Preferences

- 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

Evaluation of the Concept (1/3)

- Implemented add-on for Moodle (Version 1.6.3)
- University course about object-oriented modelling with about 400 students
- Procedure:
  - Students filled out ILS questionnaire
  - Individual course was automatically generated according to their learning styles
  - Moodle presented the adapted course (as recommendation) to each student
  - Students were nevertheless able to access all learning objects and take a different learning path

Evaluation of the Concept (2/3)

Does adaptivity have an effect on learning?

- Research design
  - Three groups:
    - Courses that fits 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)

Incorporating learning styles in Moodle (3/3)

- Results:
  - Average score on assignments & score on final exam
    - no significant difference
  - Time spent on learning activities
    - Standard > Matched
    - Mismatched > Matched
  - Number of logins
    - Standard > Matched
  - Number of visited learning activities
    - no significant difference
  - Number of requests for additional LOs
    - Mismatched > Matched

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

→ Demonstrates positive effect of adaptivity

Future Work on the Adaptation Mechanism (for Learning Communities Project)

Extending the adaptation mechanism by:

- A generic framework for considering different types of learning objects
  → new types of learning objects can be added
  → new and self-defined adaptation features can be added
- Additional involvement of learning styles
  For example, by providing learners with material to refresh their knowledge after a longer learning break
- Combining adaptivity based on learning styles with other kinds of adaptivity (context, location, ...) and other components of the project

Conclusion

- Incorporating the individual needs of students in technology enhanced learning is an important issue. Therefore, the needs of learners have to be known and a suitable adaptation strategy has to be adopted.
- Providing adaptivity in LMS combines the advantages of LMS and adaptive systems, which leads to a more supportive learning environment for learners

Questions

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