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Using Cognitive Traits for Improving the Detection of Learning Styles

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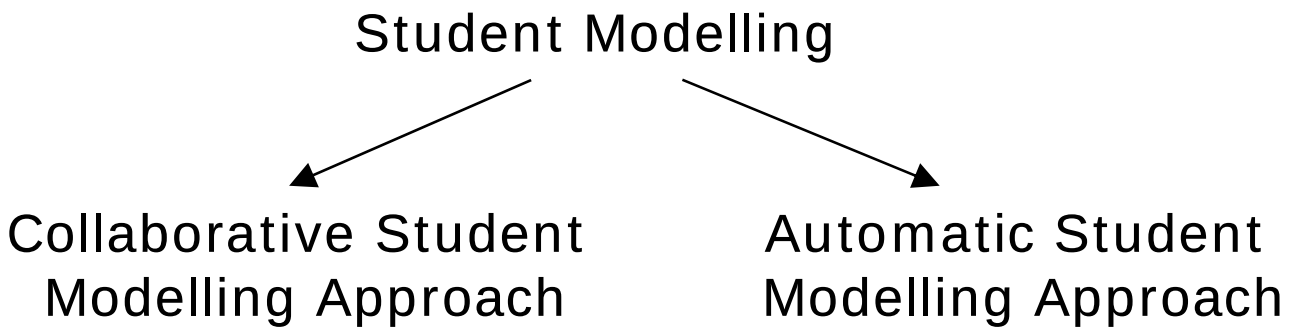
Why detecting learning styles?

- Why shall we consider learning styles in technology enhanced learning?
  - Complex and partially inconsistent field
  - Learners have different ways in which they prefer to learn
  - If these preferences are not supported, learners can have difficulties in learning
  - Previous studies showed that providing learners with courses that fit their learning styles has potential to help learners in learning

Student Modelling

- For considering learning styles in learning systems, learning styles of learners have to be known first
- Student modelling refers to the process of building and updating a student model, which includes relevant data about the student
- How to get this information?



Collaborative & Automatic Student Modelling

- Collaborative Student Modelling
  - Learners are asked to provide explicitly information about their needs and characteristics (e.g., filling out a questionnaire, performing a task, and so on)
- Automatic Student Modelling
  - The system infers the needs and characteristics automatically from the behaviour and actions of students in an online course
  - Advantage:
    - Students do not have additional effort
    - Approach is direct and free from the problem of inaccurate self-conceptions
    - Data are gathered over a period of time → more accurate
    - Dynamic aspects can be considered
  - Drawback/Challenges:
    - Getting enough reliable information to build a robust student model
    - Suggestions: use of additional sources

Aim

- Find mechanisms that use whatever information about the learner is available to get as much reliable information to build a more robust student model
- Investigated relationship between learning styles and cognitive traits

→ Additional data

→ Improve the identification process of learning styles in adaptive learning environments

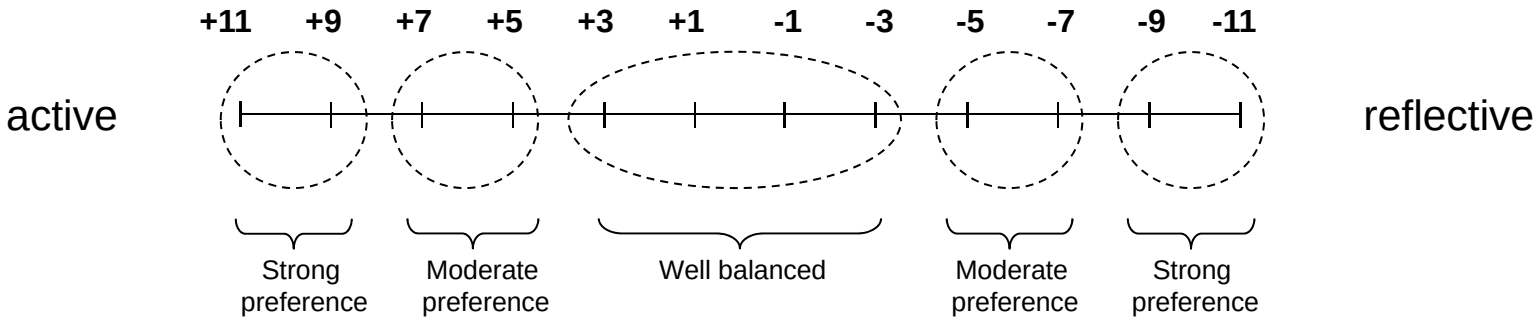
Felder-Silverman Learning Style Model

- 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

- 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
  - domain-independent

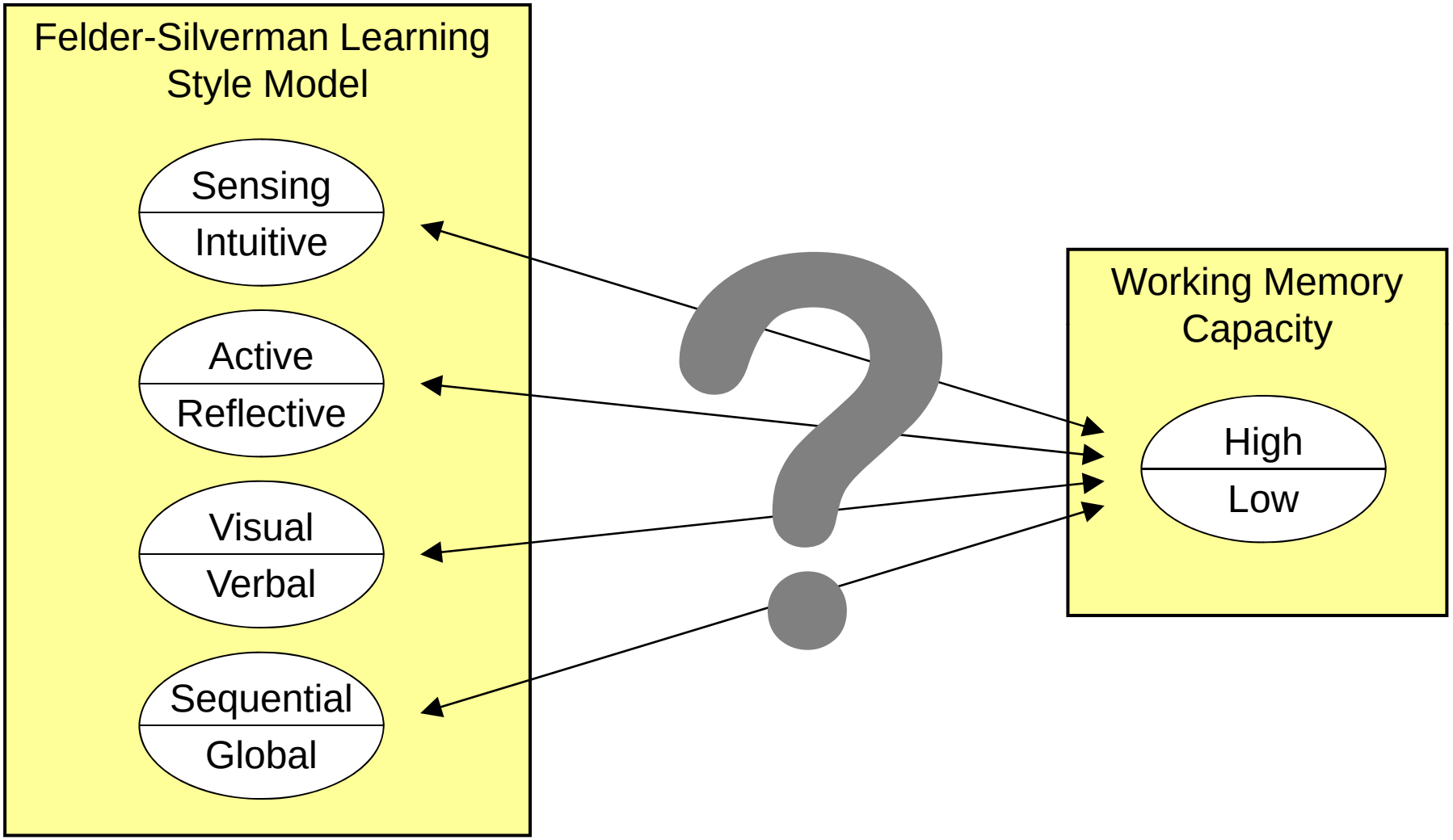
Cognitive Trait Model (CTM)

- Developed by Lin et al., 2003
- CTM is a student model that profiles learners according to their cognitive traits
- Includes cognitive traits such as
  - Working Memory Capacity
  - Inductive Reasoning Ability
  - ...
- Cognitive traits are more or less persistent
  → CTM can still be valid after a long period of time
  → CTM is domain independent and can be used in different learning environments, thus supporting life long learning

Working Memory Capacity (WMC)

- Important cognitive trait for learning
- Also known as short-term memory
- Researchers do not agree on the structure of working memory, they agree that it consists of storage and operational sub-systems
- Allows us to keep active a limited amount of information (7+/-2 items) for a brief period of time

Relationship between FSLSM and WMC



Previous Research

- Comprehensive literature review
  - Looking into existing studies that investigated relationships between learning styles, cognitive styles and cognitive traits

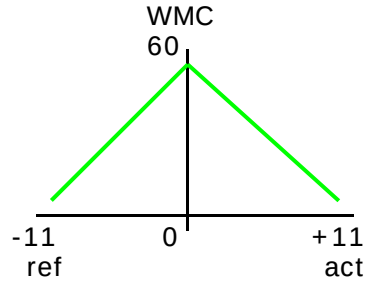
  → Indirect relationships were found
- Exploratory study with 39 students
  - Identification of learning styles through ILS questionnaire and WMC through Web-OSPAN tasks
  - Statistical analysis of data to find relationships

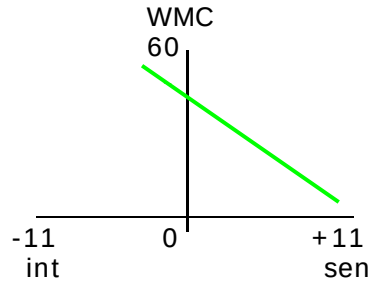
  → Relationships between learning styles and WMC were found
- Main study with 297 students
  - Identification of learning styles through ILS questionnaire and WMC through Web-OSPAN tasks
  - Detailed statistical analysis of data to find relationships

  → Relationships between learning styles and WMC were found

Overview of Results

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





Research Question

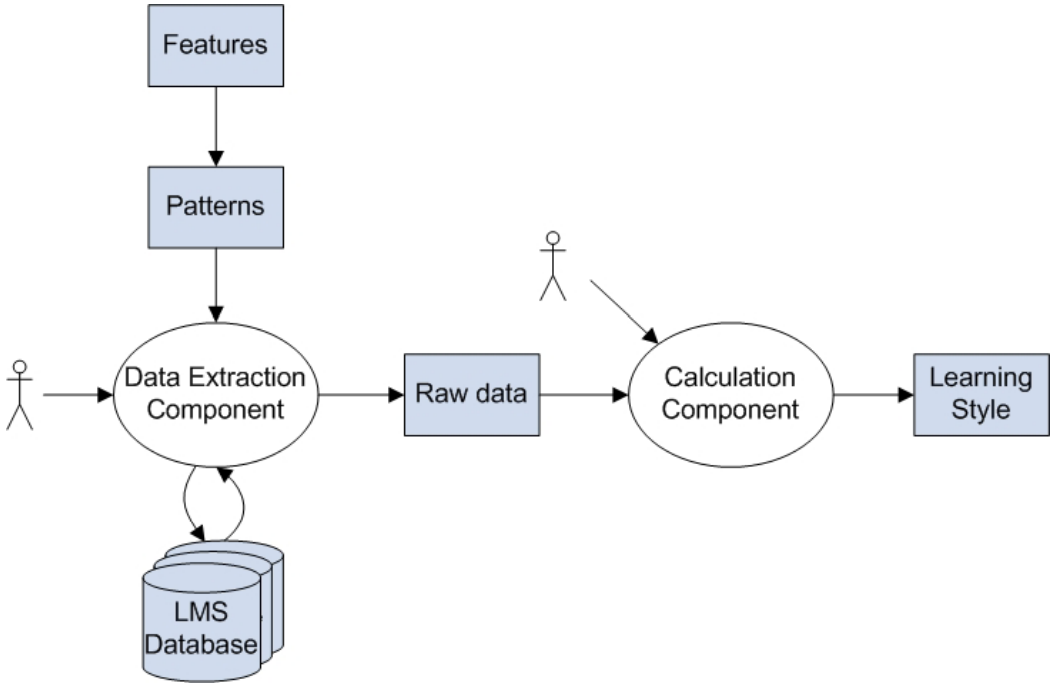
- How can we use the identified relationships in student modelling of learning styles?
- Does including these relationships has potential to improve the accuracy of automatic detection of learning styles?

Automatic Identification of Learning Styles

- Identifying learning styles is based on patterns of behaviour
- Commonly used types of learning objects were used and patterns were derived from these types of learning objects
- Overall, 27 patterns were used for the four learning style dimensions of FSLSM
- Hints about students' learning styles were calculated based on students' behaviour with respect to the identified patterns

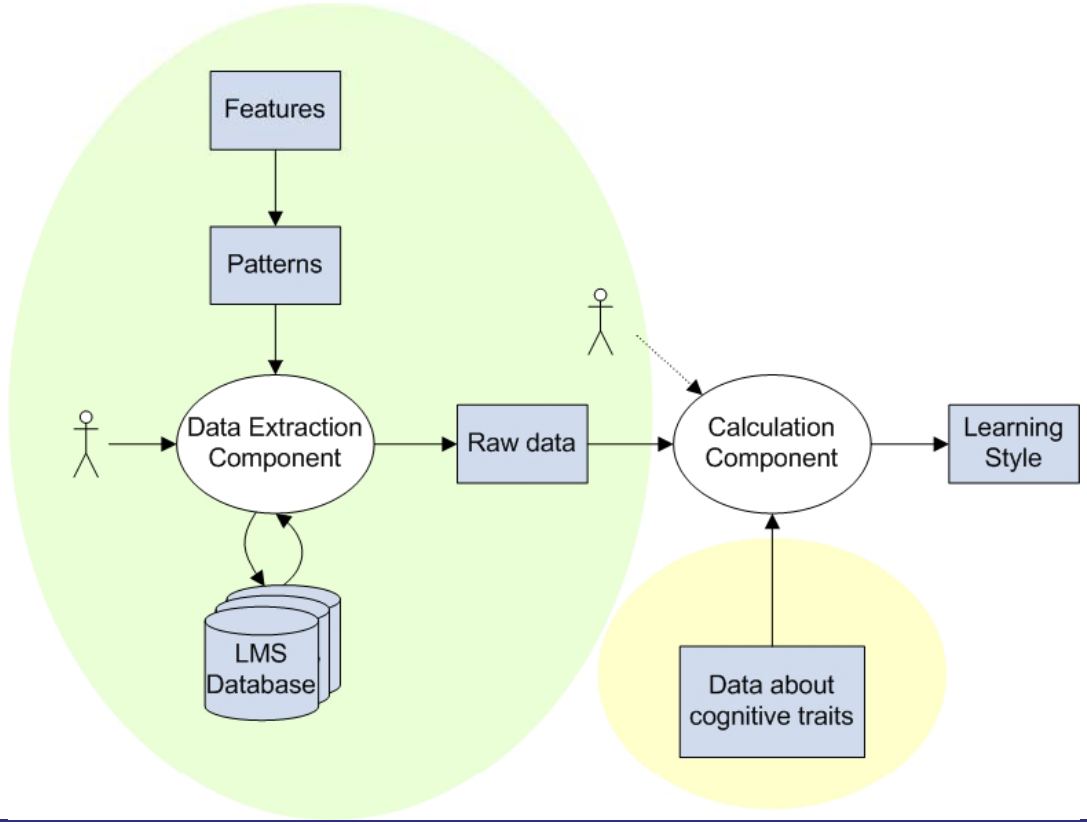
Automatic Identification of Learning Styles

- Implementation of the approach as tool



Automatic Identification of Learning Styles from Behaviour and Cognitive Traits

- Extending the approach/tool through data from cognitive traits



Experiment

- Aim:
  - demonstrate the practical use of the identified relationship between learning styles and cognitive traits and
  - demonstrate the positive effect of this relationship for identifying learning styles
- Data from 63 students
  - Data from ILS questionnaire and Web-OSPAN task
  - Behaviour data from an online course

Experiment Design

- Step1: Tool was used without considering information from cognitive traits (calculation is only based on behaviour data) and results were compared to ILS results using the following formula:

$$\frac{\sum_{i=1}^{n} Sim(LS_{predicted}, LS_{ILS})}{n} \cdot 100$$

- Step2: Tool was used with considering information from cognitive traits (calculation is based on behaviour data and cognitive traits data) and results were again compared to ILS results

Experiment results

	act/ref	sen/int	vis/ver
only behaviour	79.37	74.60	76.19
behaviour and cognitive traits	79.37	76.19	79.37

- No difference for act/ref dimension
- Increase in precision measure for sen/int and vis/ver dimension

→ Relatively small increase but promising results since only one “pattern” has been used

→ Results encourage incorporating also other cognitive traits

Conclusion & Future Work

- Investigated the practical use of the relationship between learning styles and cognitive traits for improving student modelling of learning styles
- Results show a small increase of the accuracy which is a promising results, given that only one cognitive traits was considered.
- Future Work
  - Include also other cognitive traits in the approach/tool for identifying learning styles
  - Investigate the act/ref dimension and its relationship to WMC