Analysing the Relationship between Learning Styles and Cognitive Traits

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Motivation

- Learners have different needs
  - Background knowledge
  - Learning goals
  - Learning styles
  - Cognitive traits
  - ...

- Incorporating these needs increase the learning progress, leads to better performance, and makes learning easier

→ Adaptive systems
For providing adaptivity, the needs and characteristics 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?

Student Modelling

- Collaborative Student Modelling Approach
- Automatic Student Modelling Approach
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
  - **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

- Investigate relationship between learning styles and cognitive traits
  - Additional data
  - Improve the identification process of learning styles and cognitive traits in adaptive learning environments
Relationship between Cognitive Traits and Learning Styles

Why shall we relate cognitive traits and learning styles?

- Case 1: Only one kind of information (CT or LS) can be detected in the system
  → Get some hints about the other one

  \[ \text{CT} \rightarrow \sim \text{LS} \quad \text{or} \quad \text{LS} \rightarrow \sim \text{CT} \]

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

- Each learner has a preference on each of the four dimensions
- Dimensions:
  - Active – Reflective
    - learning by doing – learning by thinking things through
    - learning by discussing & group work – work alone
  - Sensing – Intuitive
    - concrete material – abstract material
    - more practical – more innovative and creative
    - patient and careful/not patient and careful 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“
    - interested in details – interested in the overview
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)

- 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

Felder-Silverman Learning Style Model

- Sensing
- Intuitive
- Active
- Reflective
- Visual
- Verbal
- Sequential
- Global

Working Memory Capacity

- High
- Low
## Literature Review

<table>
<thead>
<tr>
<th>Felder-Silverman Learning Style Dimensions</th>
<th>High WMC</th>
<th>Low WMC</th>
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<tr>
<td>Reflective</td>
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Relationship between FSLSM and WMC

Felder-Silverman Learning Style Model

- Sensing
- Intuitive
- Active
- Reflective
- Visual
- Verbal
- Sequential
- Global

Working Memory Capacity

- High
- Low
Study Design

- Analyse the relationship between learning styles and working memory capacity by the use of real data
- Compare results of analyses with results from literature review
- 297 students from Vienna University of Technology participated
- Students were asked to fill out a questionnaire in order to detect their learning styles and perform a psychometric test in order to measure their WMC
Identify Learning Styles according to FSLSM

- **Index of Learning Style (Felder & Soloman, 1997)**
  - Commonly used instrument for identifying learning styles according to FSLSM
  - 44-item questionnaire (11 questions per dimension)
  - Each learner is characterised by four values between +11 and -11
  - Questionnaire is available in German
Identifying working memory capacity

- From Simple Span Task to Web-OSpan Task
  - Simple Span Task: participants have to remember a series of stimulus items (digits or words)
  - Complex Span Task: Researchers agree that WMC covers also operational aspects rather than only storage aspects
  - Several versions exist, the operation word span task becomes the most popular task to measure WMC

- Web-OSpan Task (Lin, 2005)
  - Simple operations such as $1+(2*3) = 6$ are presented
  - Participant has to answer with true or false
  - After each operation, a word is displayed
  - After 2-6 operations, all words have to be typed in (in the correct order)
  - Overall 60 operations and 60 words
Identifying working memory capacity

- **Web-OSpan Task**
  - **Measures:**
    - Total number of correct recalled words
    - Total number of correct calculations (process measure)
    - Maximum set size the subject had the words correctly recalled (set size memory span)
    - Mean response latency
    - Partial correct memory span
  - WMC is measured by the number of correct recalled words
- Available in German
Method for Statistical Data Analysis

**Data Cleansing**
- Discard data from students who made more than 15 mistakes in the calculations or spend less than 5 minutes at ILS
  → 225 students
- Improved reliability of ILS through removing weak reliable questions
  - 1 question from active/reflective dimension
  - 1 question from sensing/intuitive dimension
  - 3 questions from visual/verbal dimension
  - 2 questions from sequential/global dimension
Method for Statistical Data Analysis

- **General Analysis**
  - Correlation analysis (Pearson’s & rank correlation)

- **In-depth Analysis**
  - Three groups were build for each dimension (e.g., active, balanced, reflective)
  - Chi-Square test was used to identify differences between the groups
  - If differences exist
    - Correlation analysis between WMC and the absolute values of ILS dimensions
    - Split data into two subsets (positive pole & balanced; negative pole and balanced)
    - For each subset, correlation analysis and group comparison methods were performed
In-depth Analysis for vis/ver dimension

- In-depth Analysis
  - For visual/verbal dimension:
    - Used correlation of frequencies in order to prove one-directional relationship
      - Separate visual and verbal learners
        - For each subset, the number of learners in WMC groups was calculated
        - Rank correlation analysis was performed in order to find a correlation between frequencies of WMC groups for e.g. verbal learners
        - Results of verbal and visual learners were compared
          - Same was done for the two subsets with high and low WMC learners
Results – Measures of Web-OSPAN task

- General Analysis
  - Correlation with total number of recalled words

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<tr>
<th>Measure</th>
<th>Corr. Value</th>
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<td>set size memory span</td>
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<tr>
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<td>rho=0.757</td>
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<td>partial correct memory span</td>
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<td></td>
<td>rho=0.883</td>
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<td>Mean response time</td>
<td>r = -0.361</td>
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<tr>
<td>process measure</td>
<td>tau=0.191</td>
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<tr>
<td></td>
<td>rho=0.258</td>
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</table>
Results – Active/Reflective Dimension

- General Analysis: No significant correlation
- In-depth Analysis
  - Chi-Square Test: significant result → difference between active/balanced/reflective group
    - Correlation analysis between WMC and the absolute act/ref values: significant negative results for WMC, set size memory span, partial correct memory span
      - balanced learning style <-> low WMC
      - strong active or reflective learning style <-> high WMC
    - Subset (active & balanced)
      - Correlation analysis: significant negative result for WMC, set size memory span, partial correct memory span, process measure
        - active learning styles <-> low WMC
        - balanced learning style <-> high WMC
      - Mann-Whitney U test (comparing low and high WMC over active/balanced values):
        - Low WMC -> active learning style
        - High WMC -> balanced learning style
    - Subset (reflective & balanced)
      - Correlation analysis: significant positive result for WMC (according to Spearman’s rho)
        - Reflective learning style -> low WMC
        - Balanced learning style -> high WMC
      - T test (comparing reflective and balanced group over WMC)
        - Reflective learning style -> low WMC
        - Balanced learning style -> high WMC

→ balanced learning style <-> low WMC
→ active learning style <-> high WMC
→ reflective learning style <-> high WMC
Results – Sensing/Intuitive Dimension

- General Analysis: significant negative correlation for size set memory span
- In-depth Analysis
  - Chi-Square Test: significant result → difference between active/balanced/reflective group
  - Correlation analysis between WMC and the absolute sen/int values: not significant
    → indication for linear correlation
  - Subset (active & balanced)
    - Correlation analysis: significant negative result for set size memory span
      Sensing learning styles <-> low WMC
      balanced learning style <-> high WMC
    - Mann-Whitney U test (comparing low and high WMC over sensing/balanced values):
      Low WMC -> sensing learning style
      High WMC -> balanced learning style
    - T test (comparing reflective and balanced group over WMC)
      Sensing learning style -> low WMC
      Balanced learning style -> high WMC
  - Subset (reflective & balanced)
    - Correlation analysis: significant negative result for mean response latency

→ Sensing learning style <-> low WMC
→ The more balances, the higher is WMC
→ No evidence about intuitive part
Results – Visual/Verbal Dimension

- General & In-depth Analysis: no significant results for bi-directional relationship

- Analysis of correlations of frequencies in sub-datasets (→ one-directional relationship)
  - Subset (low & high WMC)
    - Correlation of frequencies of vis/ver preferences: strong positive correlation for low and high WMC → argued by the fact that more learners have visual than verbal preference
  - Subset (visual and verbal learning style)
    - Correlation of frequencies of WMC groups
      - Significant positive correlation for learners with verbal preference → for verbal learners a high frequency is associated with high WMC, whereas few verbal learners have low WMC
      - No significant correlation for visual learners

→ Verbal learning style → high WMC
Results – Sequential/Global Dimension

- General & In-depth Analysis: no significant results
- Disagreement with literature (indicating that a correlation between sequential learners and high WMC as well as global learners and low WMC)
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

→ Identified relationships can be included in the detection process of learning styles and cognitive traits
→ Improve student modelling process and lead to a more robust student model
Conclusion & Future Work

- Investigated the relationship between FSLSM and WMC by conducting a study with 297 students
- Results show a relationship between WMC and active/reflective, sensing/intuitive and visual/verbal dimension, whereas no relationship was found for the sequential/global dimension
- Relationships provide additional information about the learners which can be used to improve the detection process of learning styles or/and cognitive traits
- Future Work
  - Include the findings of this study to improve the detection process of cognitive traits in CTM
  - Include the findings of this study to improve the detection process of learning styles
  - More granular analysis by considering specific characteristics within the FSLSM dimensions