Adaptivity in Learning Management Systems focusing 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 incorporate learning styles
  - Teachers should have as little as possible additional effort
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:

  - active:
    - +11: Strong preference
    - +9: Strong preference but no support
    - +7: Moderate preference
    - +5: Well balanced
    - +3: Moderate preference
    - +1: Strong preference
    - -1: Moderate preference
    - -3: Well balanced
    - -5: Moderate preference
    - -7: Strong preference
    - -9: Strong preference but no support
    - -11: Problems

  - reflective:

  → 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 = Detecting Learning Styles**

- **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

<table>
<thead>
<tr>
<th>Active/Reflective</th>
<th>Sensing/Intuitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visits of forum (act)</td>
<td>Correct answers: facts/concepts (sen)</td>
</tr>
<tr>
<td>Postings in forum (act)</td>
<td>Revisions of marked tests (sen)</td>
</tr>
<tr>
<td>Visits of chat (act)</td>
<td>Revisions of self-assessment tests (sen)</td>
</tr>
<tr>
<td>Postings in chat (act)</td>
<td>Duration of marked tests (sen)</td>
</tr>
<tr>
<td>Visits of exercise (act)</td>
<td>Duration of self-assessment tests (sen)</td>
</tr>
<tr>
<td>Time spent on exercises (act)</td>
<td>Visits of exercises (int)</td>
</tr>
<tr>
<td>Time spent on examples (ref)</td>
<td>Time spent on exercises (int)</td>
</tr>
<tr>
<td>Time spent on content objects (ref)</td>
<td>Visits of exercises (int)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sensing/Intuitive</th>
<th>Visual/Verbal</th>
</tr>
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<tbody>
<tr>
<td>Correct answers: facts/concepts (sen)</td>
<td>Visits of forum (ver)</td>
</tr>
<tr>
<td>Revisions of marked tests (sen)</td>
<td>Postings in forum (ver)</td>
</tr>
<tr>
<td>Revisions of self-assessment tests (sen)</td>
<td>Visits of chat (ver)</td>
</tr>
<tr>
<td>Duration of marked tests (sen)</td>
<td>Postings in chat (ver)</td>
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<tr>
<td>Duration of self-assessment tests (sen)</td>
<td>Time spent on graphics (vis)</td>
</tr>
<tr>
<td>Visits of exercises (int)</td>
<td>Correct answers: graphics (vis)</td>
</tr>
<tr>
<td>Time spent on exercises (int)</td>
<td></td>
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<tr>
<td>Visits of exercises (int)</td>
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<tr>
<td>Visits of self-assessment tests (sen)</td>
<td></td>
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<tr>
<td>Visits of examples (sen)</td>
<td></td>
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<tr>
<td>Time spent on examples (sen)</td>
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<table>
<thead>
<tr>
<th>Sequential/Global</th>
<th>Visual/Verbal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct answers: detail/overview (seq)</td>
<td>Visits of forum (ver)</td>
</tr>
<tr>
<td>Performance of marked tests (seq)</td>
<td>Postings in forum (ver)</td>
</tr>
<tr>
<td>Performance of self-assessment tests (seq)</td>
<td>Visits of chat (ver)</td>
</tr>
<tr>
<td>Visits of outline (glo)</td>
<td>Postings in chat (ver)</td>
</tr>
<tr>
<td>Time spent on outline (glo)</td>
<td>Time spent on graphics (vis)</td>
</tr>
<tr>
<td>Skips learning objects (glo)</td>
<td>Correct answers: graphics (vis)</td>
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<tr>
<td>Visits of course overview page (glo)</td>
<td></td>
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<tr>
<td>Time spent on course overview page (glo)</td>
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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

  \[
  \begin{align*}
    \text{CT} & \rightarrow \text{LS} \quad \text{or} \quad \text{LS} & \rightarrow & \text{CT}
  \end{align*}
  \]

- **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

Detection of CT

\[
\begin{align*}
  \ldots & \ldots & \ldots \\
  \text{LS} & & \end{align*}
\]

and

Detection of LS

\[
\begin{align*}
  \ldots & \ldots & \ldots & \ldots \\
  \text{CT} & & & \end{align*}
\]
Relationship between FSLSM and WMC

Felder-Silverman Learning Style Model

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

Working Memory Capacity

- High
- Low
# Literature Research

## Felder-Silverman Learning Style Dimensions

<table>
<thead>
<tr>
<th>High WMC</th>
<th>Low WMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflective</td>
<td>Active</td>
</tr>
<tr>
<td>Beacham, Szumko, and Alty (2003)</td>
<td></td>
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<tr>
<td>Hadwin, Kirby, and Woodhouse (1999)</td>
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<tr>
<td>Kolb (1984)</td>
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<tr>
<td>Summervill (1999)</td>
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<tr>
<td>Witkin et al. (1977)</td>
<td></td>
</tr>
<tr>
<td>Intuitive</td>
<td>Sensing</td>
</tr>
<tr>
<td>Bahar and Hansell (2000)</td>
<td></td>
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<tr>
<td>Davis (1991)</td>
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<tr>
<td>Ford and Chen (2000)</td>
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<tr>
<td>Hudson (1966)</td>
<td></td>
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<tr>
<td>Kinshuk and Lin (2005)</td>
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<td>Scandura (1973)</td>
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</tr>
<tr>
<td>Witkin et al. (1977)</td>
<td></td>
</tr>
<tr>
<td>Verbal or Visual</td>
<td>Visual</td>
</tr>
<tr>
<td>Beacham, Szumko, and Alty (2003)</td>
<td></td>
</tr>
<tr>
<td>Simmons and Singleton (2000)</td>
<td></td>
</tr>
<tr>
<td>Wey and Waugh (1993)</td>
<td></td>
</tr>
<tr>
<td>Sequential</td>
<td>Global</td>
</tr>
<tr>
<td>Beacham, Szumko, and Alty (2003)</td>
<td></td>
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<tr>
<td>Ford and Chen (2000)</td>
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<tr>
<td>Huai (2000)</td>
<td></td>
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<tr>
<td>Liu and Reed (1994)</td>
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<tr>
<td>Mortimore (2003)</td>
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<tr>
<td>Witkin et al. (1977)</td>
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## Cognitive Styles

<table>
<thead>
<tr>
<th>High WMC</th>
<th>Low WMC</th>
</tr>
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<tbody>
<tr>
<td>Field-independent</td>
<td>Field-dependent</td>
</tr>
<tr>
<td>Al-Naeme (1991)</td>
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<tr>
<td>Bahar and Hansell (2000)</td>
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<tr>
<td>El-Banna (1987)</td>
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<tr>
<td>Pascual-Leone (1970)</td>
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<tr>
<td>Divergent</td>
<td>Convergent</td>
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<tr>
<td>Bahar and Hansell (2000)</td>
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<tr>
<td>Serial</td>
<td>Holistic</td>
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<tr>
<td>Huai (2000)</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
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)
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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