Incorporating Learning Styles in Learning Management Systems

Sabine Graf
Vienna University of Technology
Women’s Postgraduate College for Internet Technologies
Vienna, Austria
graf@wit.tuwien.ac.at
Research assistant at Vienna University of Technology

Background in Information Systems

Research interests

- Adaptivity in e-learning systems
- Student modelling
- Learning styles and cognitive traits
- Peer assessment
- Game-based learning
- Artificial intelligence
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
  - Development of course is complicated
  - 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 can we incorporate learning style in LMS?

Two steps:
- Detection of learning styles
  - Collaborative student modelling (questionnaires)
  - Automatic student modelling
    - Get information from behaviour of students
    - Get information from additional sources
- Providing adaptivity according to the identified learning styles

General aims:
- Concept for LMS in general, implementation in Moodle (Case studies are running)
- Show how to extend LMS, so that they are able to identify learning styles and generate adaptive courses automatically
- Teachers should have as little as possible additional effort
Felder-Silverman Learning Style Model (1/2)

- FSLSM is one of the most often used learning style models in technology enhanced learning
- 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:

- Differences to other learning style models:
  - describes learning style in more detail
  - represents also balanced preferences
  - describes tendencies
  - is often used in e-learning
How to identify learning styles?

- Collaborative student modelling
  - “Index of Learning Styles” 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 behavior
  - Advantages of this approach:
    - Students have no additional effort
    - Can be updated frequently → higher tolerance
  - Problems with this approach:
    - Get enough reliable information to build a robust student model
      - Certain amount of data about the behavior
      - Additional information related to learning styles
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
  - Examples
  - Tests (self-assessment and marked)
  - Exercises
  - Communication tools (forum, chat)
### Patterns of Behaviour

<table>
<thead>
<tr>
<th><strong>Active/Reflective</strong></th>
<th><strong>Sensing/Intuitive</strong></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 self-assessment tests (sen)</td>
</tr>
<tr>
<td></td>
<td>Visits of examples (sen)</td>
</tr>
<tr>
<td></td>
<td>Time spent on examples (sen)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Sequential/Global</strong></th>
<th><strong>Visual/Verbal</strong></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>Visits of course overview page (glo)</td>
</tr>
<tr>
<td>Skips learning objects (glo)</td>
<td>Time spent on course overview page (glo)</td>
</tr>
<tr>
<td>Visits of course overview page (glo)</td>
<td>Correct answers: graphics (vis)</td>
</tr>
<tr>
<td>Time spent on course overview page (glo)</td>
<td></td>
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<td></td>
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</table>
Tool Architecture

Features

Patterns

Data Extraction Component

Raw data

Calculation Component

Learning Style

LMS Database
Evaluation and application 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 study with about 120 students is running
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.
- Most important abilities for learning:
  - Working memory capacity
  - Inductive reasoning ability
  - Information processing speed
  - Associative learning skills
Research about cognitive traits

- **Cognitive Trait Model (CTM)**
  - Student model that includes information about cognitive traits
  - Gathers information about the learner according to behaviour
  - Cognitive traits are stored in CTM

  → CTM can still be valid after a long period of time
  → CTM is domain independent and can be used in different learning environments, thus supports life long learning
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

  ![Diagram](CT → LS or LS → CT)

- **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

  ![Diagram](Detection of CT and Detection of LS)
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

<table>
<thead>
<tr>
<th>Field-independent</th>
<th>Field-dependent</th>
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<tbody>
<tr>
<td>Al-Naeme (1991)</td>
<td></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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<td>Pascual-Leone (1970)</td>
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<td>Bahar and Hansell (2000)</td>
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<tr>
<th>Serial</th>
<th>Holistic</th>
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<tbody>
<tr>
<td>Huai (2000)</td>
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</table>

### 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>
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<td>Reflective: Witkin et al. (1977)</td>
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<table>
<thead>
<tr>
<th>Intuitive</th>
<th>Sensing</th>
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<td>Intuitive: Witkin et al. (1977)</td>
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<table>
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<tr>
<th>Verbal or Visual</th>
<th>Visual</th>
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<tr>
<td>Verbal or Visual: Wey and Waugh (1993)</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
    - Simple operations such as \(1+(2\times3) = 6\) 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
Results

- **Active/reflective:**
  - Low WMC $\leftrightarrow$ strong active
  - Low WMC $\leftrightarrow$ 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

![Diagram showing data extraction and calculation components]
How to provide adaptivity?

- Add-on to an existing LMS which enables the 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
Overview
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
Adaptivity regarding learning styles

- Two different approaches to provide adaptivity
  - Provide courses that fit to the preferred learning styles
    → Aims at short term goal:
      Makes learning easier and increases the progress
  - Provides courses that do not fit to the learners’ preferred styles
    → Aims at long term goal:
      challenging learners and encouraging them to train
      learning according to their weak preferences provides
      them with important life skills
Incorporating learning styles in Moodle (1/2)

- 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
- Courses were automatically generated according to their learning styles
- Moodle presented the adapted course (as recommendation) to each student
- Students are nevertheless able to access all learning objects and take a different learning path
Incorporating learning styles in Moodle (2/2)

- Research question
  - Does adaptivity have an effect on learning?

- Research design
  - Three groups:
    - Courses that fit to the students’ learning styles
    - Courses that do not fit to the students’ learning styles (challenge learners)
    - Standard course which includes all learning objects

- Aims of future research
  - Show the effects of the different groups of student with respect to their learning styles
  - Finding differences between the groups (e.g. marks, time students spent on the course, how often they took an alternative learning path, ...)


Conclusion

- Incorporating the individual needs of students in e-education 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

Sabine Graf
http://wit.tuwien.ac.at/people/graf
graf@wit.tuwien.ac.at