Adaptive and Personalized Learning based on Students’ Characteristics

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Adaptivity and Personalization in Learning Systems

How can we make learning systems more adaptive, intelligent and personalized

- In different settings such as desktop-based, mobile and ubiquitous settings
- In different situations such as for formal, informal and non-formal learning
- Based on a rich student model that combines learner information and context information
- Supporting learners as well as teachers
- Using techniques from artificial intelligence, data mining, visualization, etc.
- Develop approaches, add-ons and mechanisms that extend existing learning systems
Core Research Topics

Identification of students’ characteristics and context

- Learning styles
- Cognitive traits
- Motivational aspects
- Context information (environmental context & device functionalities)
Core Research Topics

- Provision of Adaptive and Intelligent Functionality
  - Learning styles
  - Cognitive traits
  - Motivational aspects
  - Context information (environmental context & device functionalities)
  - Combining students’ characteristics with context

- Learning Analytics
  - Enhancing the Accessibility of Educational Log Data for Investigating Effective Course Design and Teaching Strategies
  - Identification of at-risk students
Adaptive and Personalized Learning based on Students’ Learning Styles
Adaptivity and Personalization based on learning styles

- Automatic identification of learning styles based on students’ behaviour

- Adaptive course provision based on learning styles [Collaboration with Leibniz University Hannover; Ting-Wen Chang, Jeff Kurcz]

- Adaptive recommendations for teachers to make their courses better support students with different learning styles [Moushir El-Bishouty, Kevin Saito]
Automatic Identification of Learning Styles

- Learning styles questionnaires have several disadvantages (e.g., students don’t like them, non-intentional influences, can be done only once)

- Automatic modelling
  - What are students really doing in an online course?
  - Infer their learning styles from learners’ behaviour

- Benefits of automatic student modelling
  - No additional effort for students
  - More accurate results

- General Goal
  - Developing an approach for learning systems in general
  - Implementing and evaluating this approach in Moodle
  - Developing a tool which can be used by teachers in order to identify students’ learning styles
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“
Automatic Identification of Learning Styles

- Identifying learning styles is based on patterns of behaviour.
- Commonly used types of learning objects were used (Content objects, Outlines, Examples, Self-assessment tests, Exercises, Discussion forum) and relevant patterns were derived from these types of learning objects.
- Overall, 27 patterns were used for the four learning style dimensions.
- Calculation of learning styles is based on hints from patterns.
- A simple rule-based mechanism is used for this calculation.
## Determining Relevant Behaviour

<table>
<thead>
<tr>
<th>Active/Reflective</th>
<th>Sensing/Intuitive</th>
<th>Visual/Verbal</th>
<th>Sequential/Global</th>
</tr>
</thead>
<tbody>
<tr>
<td>selfass_visit (+)</td>
<td>ques_detail (+)</td>
<td>forum_visit (-)</td>
<td>ques_detail (+)</td>
</tr>
<tr>
<td>exercise_visit (+)</td>
<td>ques_facts (+)</td>
<td>forum_stay (-)</td>
<td>ques_overview (-)</td>
</tr>
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<td>ques_concepts (-)</td>
<td>forum_post (-)</td>
<td>ques_interpret (-)</td>
</tr>
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<td>selfass_visit (+)</td>
<td>ques_graphics (+)</td>
<td>ques_develop (-)</td>
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<td>content_visit (-)</td>
<td>selfass_result_duration (+)</td>
<td>ques_text (-)</td>
<td>outline_visit (-)</td>
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<tr>
<td>content_stay (-)</td>
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<td>outline_stay (-)</td>
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<td>ques_rev_later (+)</td>
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<td>overview_visit (-)</td>
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<td>overview_stay (-)</td>
</tr>
<tr>
<td>selfass_twice_wrong (+)</td>
<td>example_visit (+)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>forum_visit (-)</td>
<td>example_stay (+)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>forum_post (+)</td>
<td>content_visit (-)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>content_stay (-)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Evaluation

- Study with 75 students
  - Let them fill out the ILS questionnaire
  - Tracked their behaviour in an online course
- Using a measure of precision
  \[
  \text{Precision} = \frac{\sum_{i=1}^{n} \text{Sim}(LS_{predicted}, LS_{ILS})}{n}
  \]
- Looking at the difference between results from ILS and automatic approach
- Results

<table>
<thead>
<tr>
<th></th>
<th>act/ref</th>
<th>sen/int</th>
<th>vis/ver</th>
<th>seq/glo</th>
</tr>
</thead>
<tbody>
<tr>
<td>comparison between ILS and automatic approach</td>
<td>79.33%</td>
<td>77.33%</td>
<td>76.67%</td>
<td>73.33%</td>
</tr>
</tbody>
</table>

→ suitable instrument for identifying learning styles
Tool for Identifying Learning Styles

- Developed a stand-alone tool for identifying learning styles in learning systems
Adaptive Course Provision based on Learning Styles

- Develop a mechanism that enables learning systems to automatically generate adaptive courses

General goals:
- Mechanism should be applicable for different learning systems
- Mechanism should ask teachers for as little as possible additional effort

Benefits:
- Teachers can continue using their courses in existing learning systems
- Students get personalized support with respect to their learning styles
Demo
Analyzing Course Contents in LMS with Respect to Learning Styles

- LMSs contain tons of existing courses but very little attention is paid to how well these courses actually support learners.

- Research Aim:
  
  - Provide teachers with a tool to see how well their courses supports students with different learning styles and their cohort of students.
  - Investigate how to improve their courses.
  - Get recommendations on how to improve their courses.
Demo

Demo ...
Adaptive and Personalized Learning based on Students’ Cognitive Abilities
Adaptivity and Personalization based on cognitive abilities

- Automatic identification of cognitive abilities based on students’ behaviour in an online course [Ting-Wen Chang]
- Providing teachers with recommendations about how to consider students’ cognitive abilities [Ting-Wen Chang]
- Adaptive course provision based on students’ cognitive abilities [Ting-Wen Chang, Jeff Kurcz]
Automatic Identification of Working Memory Capacity (WMC)

- WMC is an important trait for learning
- Learners with high WMC can remember almost double the amount of information than learners with low WMC
- However, typically learning systems do not consider this individual differences in WMC
- Research Aim:
  - Identify WMC automatically based on students’ behaviour in a course
  - Provide teachers with recommendations on how to help students
  - Provide students with adaptive support to accommodate their WMC
Automatic Identification of Working Memory Capacity (WMC)

- Monitor students’ behaviour for indications of low or high WMC:
  - Linear/non-linear navigation
  - Constant reverse navigation
  - Simultaneous tasks
  - Ability to retrieve information effectively from long-term memory
    - Recall information from different sessions
    - Revisiting already learned materials in different session
  - Relationship with learning style
Calculating WMC

Measure Total WMC of a student from all learning sessions (LSs)

\[
\text{Total WMC} = \frac{\sum_{i=1}^{n} \text{WMC}_{LS_i} \times w_i}{\sum_{i=1}^{n} w_i} = \frac{0.73 \times 11 + 0.75 \times 14 + 0.47 \times 6}{11 + 14 + 6} = \frac{21.35}{31} = 0.69 \text{ (HWMC)}
\]

\[
\begin{cases} 
    \text{HWMC if } \text{WMC}_{LS_i} > 0.5 \\
    \text{LWMC if } \text{WMC}_{LS_i} < 0.5 \\
    \text{Blanced if } \text{WMC}_{LS_i} = 0.5
\end{cases}
\]
Recommendations for Teachers based on Students’ Cognitive Abilities

Once WMC is identified, we also want to use it to provide teachers with information and recommendations.

Research Aim

- Points out learning sessions/chapters where students’ behaviour does not match with their identified WMC.
- Provide teachers with recommendations on how to support students with respect to their WMC.
Demo

<table>
<thead>
<tr>
<th>Learning Pattern Statistics</th>
<th>WMC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Demo ...
Automatic Recommendations based on Students’ Cognitive Abilities

- **Research aim**
  - Provide students with automatic recommendations while they are learning

- **Adaptive mechanism**
  - What recommendation shall the system show?
  - When shall the system provide a recommendation?
  - Do recommendations help students?
What recommendations?

<table>
<thead>
<tr>
<th>No.</th>
<th>Asking the student to</th>
<th>When (before/after learning)</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td><strong>take notes</strong> when he/she learns a learning object</td>
<td>before</td>
<td>probability-based</td>
</tr>
<tr>
<td>R2</td>
<td><strong>request help</strong> if he/she have any question by posting or asking teachers about this learning object</td>
<td>after</td>
<td>probability-based, time-based</td>
</tr>
<tr>
<td>R3</td>
<td><strong>post the ideas</strong>, thought, or reflection about what he/she learnt in this learning object</td>
<td>after</td>
<td>probability-based</td>
</tr>
<tr>
<td>R4</td>
<td><strong>summarize</strong> what he/she learnt about this learning object</td>
<td>after</td>
<td>probability-based, time-based</td>
</tr>
<tr>
<td>R5</td>
<td><strong>rehearsal by revisiting</strong> the content of this learning object</td>
<td>after</td>
<td>time-based</td>
</tr>
<tr>
<td>R6</td>
<td><strong>use concept/mind maps</strong> to easier remember content of this learning object</td>
<td>after</td>
<td>probability-based</td>
</tr>
</tbody>
</table>
When to show a recommendation?

- Idea is to show a recommendation at certain times either before or after a learning object has been viewed

- Two methods for deciding on when to show a recommendation
  - Time-based (how much time has a student spent on a learning object)
  - Probability-based (based on students’ WMC)
When to present which recommendations?

- For each type of learning object, it has been determined whether a recommendation makes sense or not.
- For each type of learning object, recommendations are ranked based on how well they fit for a learning object.
- Consider whether time-based or probability-based method is activated.
- Consider whether the next learning object is a discussion forum or not.
- Consider whether a recommendation has been followed or not.
Questions

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