Adaptive and Intelligent Technologies for Learners and Teachers

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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
Adaptivity and Personalization in Learning Systems

- Considering students’ characteristics and context
  - Learning styles
  - Cognitive traits
  - Motivational aspects
  - Communication patterns and group progress (in collaborative learning)
  - Context information (environmental context & device functionalities)
  - Combining students’ characteristics with context

- Providing teachers with intelligent support
  - Awareness of course quality
  - Awareness of students’ progress, characteristics and needs
  - Easy access to educational log data
  - Identification of students at risk of failing a course

- Different settings
  - Learning management systems
  - Mobile / Ubiquitous learning
Adaptivity and Personalization in Learning Systems

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  - **Learning styles**
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  - Awareness of course quality
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- Different settings
  - **Learning management systems**
  - Mobile / Ubiquitous learning
Why aiming at enabling learning management systems to adapt to students’ characteristics?
Why Learning Management Systems?

- are used by most educational institutions
- Examples: Moodle, Blackboard, Sakai, ATutor
- are developed to support teachers to create, administer and teach online courses
- provide a lot of different features
- domain-independent
- provide only little or in most cases no adaptivity
Why Learning Styles?

- Complex research area with several open research questions
- 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
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:

  - Active:
    - +11: Strong preference
    - +9: Moderate preference
    - +7: Well balanced
    - +5: Moderate preference
    - +3: Moderate preference
    - +1: Moderate preference
    - -1: Well balanced
    - -3: Moderate preference
    - -5: Moderate preference
    - -7: Moderate preference
    - -9: Strong preference
    - -11: Strong preference

  - Reflective:
    - +11: Strong preference
    - +9: Moderate preference
    - +7: Well balanced
    - +5: Moderate preference
    - +3: Moderate preference
    - +1: Moderate preference
    - -1: Well balanced
    - -3: Moderate preference
    - -5: Moderate preference
    - -7: Moderate preference
    - -9: Strong preference
    - -11: Strong preference

→ Strong preference but no support → problems
Differences to other learning style models:
- Combines major learning style models (Kolb, Pask, Myers-Briggs Type Indicator)
- New way of combining and describing learning styles
- Describes learning style in more detail (Types <-> Scale)
- Represents also balanced preferences
- Describes tendencies
- Domain-independent
- Are “flexible-stable” over time
How to automatically identify students’ learning styles?
Research Question

How to automatically identify students’ learning styles in typical LMSs?

- Develop a concept which enables LMS to automatically identify students’ learning styles from their behaviour in a course
- Keep the concept generic so that it can be used for different LMS
- Implement and evaluate the concept in one particular LMS

[Jason Bernard, Ting-Wen Chang]
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>
<tr>
<td>exercise_stay (+)</td>
<td>ques_concepts (-)</td>
<td>forum_post (-)</td>
<td>ques_interpret (-)</td>
</tr>
<tr>
<td>example_stay (-)</td>
<td>selfass_visit (+)</td>
<td>ques_graphics (+)</td>
<td>ques_develop (-)</td>
</tr>
<tr>
<td>content_visit (-)</td>
<td>selfass_result_duration (+)</td>
<td>ques_text (-)</td>
<td>outline_visit (-)</td>
</tr>
<tr>
<td>content_stay (-)</td>
<td>selfass_duration (+)</td>
<td>content_visit (-)</td>
<td>outline_stay (-)</td>
</tr>
<tr>
<td>outline_stay (-)</td>
<td>exercise_visit (+)</td>
<td></td>
<td>navigation_skip (-)</td>
</tr>
<tr>
<td>selfass_duration (-)</td>
<td>ques_rev_later (+)</td>
<td></td>
<td>overview_visit (-)</td>
</tr>
<tr>
<td>selfass_result_duration (-)</td>
<td>ques_develop (-)</td>
<td></td>
<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>
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<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
  \[
  \text{Precision} = \frac{\sum_{i=1}^{n} \text{Sim}(LS_{\text{predicted}}, LS_{\text{ILS}})}{n}
  \]
- Looking at the difference between results from ILS and automatic approach
- Results:

<table>
<thead>
<tr>
<th>Approach</th>
<th>Act/Ref</th>
<th>Sen/Int</th>
<th>Vis/Ver</th>
<th>Seq/Glo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literature-based approach</td>
<td>0.799</td>
<td>0.790</td>
<td>0.788</td>
<td>0.702</td>
</tr>
<tr>
<td>Bayesian Networks [1]</td>
<td>0.580</td>
<td>0.770</td>
<td>-</td>
<td>0.630</td>
</tr>
<tr>
<td>NBTree [2]</td>
<td>0.7</td>
<td>0.733</td>
<td>0.533</td>
<td>0.733</td>
</tr>
</tbody>
</table>


Tool for Identifying Learning Styles

- Developed a stand-alone tool for identifying learning styles in learning systems
Improvements through Computational Intelligence Techniques

- Use neural networks to classify behaviours
- Use optimization algorithms (genetic algorithms, ant colony optimization, particle swarm optimization) to find out the weight of patterns

Results:

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<td>0.799</td>
<td>0.790</td>
<td>0.788</td>
<td>0.702</td>
</tr>
<tr>
<td>Artificial Neural Networks</td>
<td>0.802</td>
<td>0.790</td>
<td><strong>0.840</strong></td>
<td><strong>0.797</strong></td>
</tr>
<tr>
<td>Genetic Algorithm</td>
<td>0.773</td>
<td>0.784</td>
<td>0.801</td>
<td>0.781</td>
</tr>
<tr>
<td>Ant Colony System</td>
<td><strong>0.808</strong></td>
<td><strong>0.804</strong></td>
<td>0.797</td>
<td>0.730</td>
</tr>
<tr>
<td>Particle Swarm Optimization</td>
<td>0.805</td>
<td>0.792</td>
<td>0.796</td>
<td>0.753</td>
</tr>
</tbody>
</table>
Visualization of Learning Style

- Teachers can see students’ learning styles
How to provide adaptive courses in learning management systems based on students’ learning styles?
Research Question

How to extend typical LMS with adaptivity based on learning styles?

- Develop a concept which enables LMS to automatically generate adaptive courses that fit students’ learning styles
- Keep the concept generic so that it can be used for different LMS
- Implement and evaluate the concept in one particular LMS

[Ting-Wen Chang, Jeff Kurcz]
Aims and Benefits

- Teachers can continue using their courses in LMS
- Students get personalized support with respect to their learning styles
- Requirements for teachers
  - Teachers shall have as little as possible additional effort
  - Provide learning objects
  - Annotate learning objects (distinguish between the objects)
How to provide adaptivity?

- Based on 12 types of learning objects which can but don’t have to be included in the course

- Providing adaptive courses through
  - adaptive annotations
  - adaptive sequencing
Adaptivity in LMSs
Evaluation and Deployment

- Evaluated with over 500 students participating in a course about object-oriented modelling

- Results show:
  - Matched Group: less time and on average equal grades
  - Mismatched Group: visited more often not recommended learning objects

→ Demonstrates positive effect of adaptivity
→ Led to several collaborations for using the adaptive mechanism
How to provide adaptive support for collaborative learning?
Motivation

- Collaborative learning is an essential aspect in the learning process, where students learn important skills such as communication and interpersonal skills.

- However, especially in distance education, working together in groups is often difficult.
Aim

- Focus on two main areas of collaborative learning:
  - Communication
  - Project management
- Aim at providing adaptive features to support individual learners and the whole group
- Research steps:
  - Develop a concept which enables LMS to automatically identify students’ learning styles from their behaviour in a course
  - Keep the concept generic so that it can be used for different LMS
  - Implement and evaluate the concept in one particular LMS

[Jeff Kurcz, Ting-Wen Chang]
Communication

- Providing a rich communication environment where students can access a variety of communication tools from one place

- Available communication tools:
  - Forum
  - Chat
  - Messages
  - Online status

- Support import of communications from external tools (e.g., emails and Skype)
Adaptive Recommendations based on Communication Patterns

- Adaptive Recommendations are provided based on communication data from students (either within the learning environment or imported)

- Three behaviors are identified:
  - Low Attendance
    - System checks how often a student attends group meetings
    - If the student missed more than 20% of the meetings, the student receives an alert when he/she is logging in
Adaptive Recommendations based on Communication Patterns

- **Significantly Less Contributions**
  - System checks how much students are contributing to discussions, using the number of postings and their length as indicators.
  - If a student contributes significantly less than others, the system provides the student with advise on how to contribute more, depending on the used communication tool.

- **Significantly More Contributions**
  - If a student contributes significantly more than others, the system identifies this student as leader and
    - provides the student with advise on how to incorporate others in the discussion, based on the used communication tool
    - advises on which students should be encouraged first
Project Management

- Provide a project management environment where students can:
  - Create tasks for their projects (either new ones or predefined ones)
See the most relevant information on the main interface (including the task name, who is assigned to the task, due date and progress)
Project Management

- Edit a task and update progress
- See statistics on the task
- Upload a file and comment on uploaded files
Ensuring Equal Workload Distribution

- One of the problems in group works is that some students do a lot of work, while others don’t do so much.
- ACS provides groups with information on the workload distributions and alerts them if there is one or more students who have significantly less or more work.

<table>
<thead>
<tr>
<th>Member</th>
<th>Assigned Hours</th>
<th>% of Workload</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eric Bondy</td>
<td>80</td>
<td>57.14</td>
<td>129%</td>
</tr>
<tr>
<td>Gary Long</td>
<td>40</td>
<td>28.57</td>
<td></td>
</tr>
<tr>
<td>Sean Smith</td>
<td>20</td>
<td>14.29</td>
<td>-43%</td>
</tr>
<tr>
<td>Sandra Young</td>
<td>0</td>
<td>0</td>
<td>-100%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>140</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>
Another problem in group works are delays, which can seriously impact the outcome/success of the project.

ACS analyses the progress and outcome of past groups who either failed or completed the project successfully.

Based on information from past groups, ACS identifies whether a group is at risk of failing.

If so, ACS alerts each team member and provides them with information on their risk level.
At-Risk Identification

Group Project

⚠ ALERT:
According to your current group progress, you are currently displaying a chance of failure based on previous cohorts progress. Please try to complete more work to ensure success.

List of Tasks

+ NEW TASK

✓ Task: Find a Research Topic
  For: eric
  Due: 7 January 2015
  Progress: 100%

✓ Task: Write a Literature Review
  For: gary
  Due: 14 January 2015
  Progress: 100%

Task: Create a System Design
  For: sean
  Due: 12 February 2015
  Progress: 50%

Task: Develop an Implementation
  For: eric
  Due: 15 February 2015
  Progress: 2%

Task: Write Final Paper
  For: sean
  Due: 6 July 2015
  Progress: 0%

Group Members | Last Online
--- | ---
eric | Online Now
gary | 21/04/15, 18:06
sean | 4/02/15, 10:25
sandra | 21/04/15, 18:34

Communication Tools

✉ Group Chat Session
✉ Group Discussion Forum

Communication History

- 30 March 2015, 11:08 AM
- 30 March 2015, 11:08 AM
- 30 March 2015, 11:09 AM
- 30 March 2015, 3:53 PM
- 3 April 2015, 10:11 AM
+ Import
Increasing Motivation

- Motivation is an important aspect in learning and, in particular in collaborative learning.
- ACS implements a motivational technique that encourages competition between groups by showing each group's progress.

![Progress Chart]

<table>
<thead>
<tr>
<th>Group</th>
<th>% Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 3</td>
<td>Progress: 90%</td>
</tr>
<tr>
<td>Group 1</td>
<td>Progress: 57%</td>
</tr>
<tr>
<td>Group 5</td>
<td>Progress: 50%</td>
</tr>
<tr>
<td>Group 2</td>
<td>Progress: 41%</td>
</tr>
<tr>
<td>Group 4</td>
<td>Progress: 35%</td>
</tr>
</tbody>
</table>
Questions

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