Learning Analytics and Academic Analytics - Investigating How Students Learn and How Effective Courses Are

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Adaptive Learning Systems

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

Providing

- adaptive courses
- individualized interfaces
- personalized recommendations
- etc.

We need to know a lot about learners and their context
Identifying Learner Characteristics and Learning Context

- How can we build and frequently update a rich learner model and context model?

- Considering students’ characteristics and context
  - Learning styles
  - Cognitive traits
  - Motivational aspects
  - Context information (environmental context & device functionalities)
  - Combining students’ characteristics with context
Intelligent Support for Learners and Teachers

- How can we provide teachers with intelligent support?
- Providing support such as:
  - 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
Learning Analytics & Big Data

- **Learning Analytics:**

  Learning analytics is the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs. (LAK 2011)

- **Big Data:**

  - Log data (AU’s LMS has about 20 million hits per month)
  - Data in different systems (e.g., LMS, student information system, etc.)
Adaptive Learning Systems

Recommend Systems

Personalization

Learning Analytics

Academic Analytics

Big Data

Intelligent Support for Teachers and Learners

Visualizations

...
How do students learn?
Investigating Students’ Behaviour

- We investigated students’ behaviour in LMSs based on
  - Number of visits of particular types of learning objects
  - Time spent on particular types of learning objects
  - Number of activities (e.g., postings, etc.)
  - Navigation patterns
  - Etc.

→ There are big differences in how students learn
Automatic Identification of Learning Styles

What does students’ behaviour tell us about their learning styles?

Can we identify students’ learning styles from their behaviour?

**Goal:**

- Design, implement and evaluate an approach to automatically identify students’ learning styles from their behaviour
- 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
  - Sensing – Intuitive
  - Visual – Verbal
  - Sequential – Global
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>
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<td>exercise_stay (+)</td>
<td>ques_concepts (-)</td>
<td>forum_post (-)</td>
<td>ques_interpret (-)</td>
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<tr>
<td>example_stay (-)</td>
<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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<td>content_stay (-)</td>
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<td>outline_stay (-)</td>
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<tr>
<td>outline_stay (-)</td>
<td>exercise_visit (+)</td>
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<td>navigation_skip (-)</td>
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<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>
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</tr>
<tr>
<td>forum_post (+)</td>
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<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

<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

![Diagram of the tool process]

- Features
- Patterns
- Data Extraction Component
- Raw data
- Calculation Component
- Learning Style
- LMS Database
Current work

- Investigate the use of Artificial Intelligence and Computational Intelligence algorithms to identify learning styles with an even higher accuracy
What else can we identify from students’ behaviour?
Automatic Identification of Working Memory Capacity (WMC)

- WMC is an important trait for learning
- WMC enables the human brain to keep active a limited amount of information for a very brief period of time
- 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
  - Solution should be independent of the learning system

[Ting-Wen Chang, Jeff Kurcz]
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)

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

\[
\begin{cases} 
\text{HWMC if } \text{WMC}_{LS_i} > 0.5 \\
\text{LWMC if } \text{WMC}_{LS_i} < 0.5 \\
\text{Balanced if } \text{WMC}_{LS_i} = 0.5
\end{cases}
\]
Evaluation

Study with 75 students
  - Let them do a Web-OSPAN task
  - Tracked their behaviour in an online course

Using Chi Square test to investigate whether there is a relationship between the results from Web-OSPAN and our approach

Results show a significant relationship ($x^2 = 4.686, df = 1, p = .03$)

→ suitable instrument for identifying working memory capacity
Visualizations

- Both approaches have been implemented into Moodle to show teachers their students’ learning styles and working memory capacity.
How to provide teachers with intelligent support?
Academic Analytics

What is academic analytics?

- Analysis of data to support educational institutions, including faculty/teachers, learning designers, decision makers, etc.
- Institution-wide and cross-course/cross-department analysis
- Includes research related to
  - Effectiveness of teaching strategies
  - Effectiveness of course designs
  - Teacher Dashboards
  - Retention and at-risk identification
  - ...
Why is a need to extend LMS to better support teachers?

- LMS are designed for supporting teachers
- However, there are still some open issues in online teaching (e.g., little feedback for teachers)
- But LMS gather huge amounts of data
- These data can be used in different ways:
  - Provide feedback about learners and their progress
  - Provide feedback about courses and their quality
  - Provide feedback on how well courses work for learners
  - Identify learners who have difficulties
  - Identify learning materials that cause difficulties
  - etc.
Analyzing Courses 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

[Moushir El-Bishouty, Kevin Saito]
Demo

Demo ...

Course Analyzer

Analysis Settings
Select a Course: TEST101 for Testing
Mode: General Cohort

Course Structure
TEST101 for Testing
- Section ID: 40
  - News Forum (Discussion Forum Activity)
  - Introduction
  - Application (Real-World Application)
  - Material (Common)
  - Media (Animation)
  - Example Quiz (Self-Assessment Test)
  - Practice (Exercise)
  - Discussion (Discussion Forum Activity)
  - Ex. Example Quiz (Self-Assessment Quiz)
  - Readings (Additional Reading Material)
  - Summary (Conclusion)
- Section 1
- Section ID: 40

Simulation Settings
Add LO (Drag and Drop):
- Discussion Forum Activity: Additional Reading Material
- Animation
- Example Quiz

Remove LO (Drag and Drop):
- Drop LO here to remove

Select the Course Suitable Learning Object Types:
- RO SAT DFA ARMI Art Ehe Eha RLA

The support level for diverse learning styles:
- Reflective
- Active
- Intuitive
- Sensing
- Visual
- Verbal
- Sequential
- Global

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- Reflective
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In online education, educators and learning designers typically don’t get much feedback on whether or not their teaching strategies and course designs are successful/helpful for students.

Learning Management Systems (LMSs) generate a lot of data.

But learning designers and educators don’t have skills to use these data (e.g.: SQL)
General Aim of Research

How to provide support for users without computer science background to access complex LMS data?

General aim:
- Design, develop and evaluate a tool that provides users with easy access to complex educational log data
- Allow users to ask “questions” to the data
- Allow users to start with easy queries and then build upon them
- Work for different LMS
- Facilitate teachers’ learning about their teaching strategies and course designers’ learning about their learning designs

[Jason Bernard, Harza Imran, Ting-Wen Chang]
Procedure

Building a profile

- Select a learning system to connect to
- Create/Select a data set (courses)
- Create/Select a patterns (queries)
Demo

Demo ...