

Adaptive and Personalized Learning based on Students' Characteristics

Sabine Graf

sabineg@athabascau.ca

Research Team:

Muhammad Anwar (PhD student)

Charles Jason Bernard (MSc student)

Moushir El-Bishouty (Postdoc)

Ting-Wen Chang (Postdoc)

Elinam Richmond Hini (MSc student & RA)

Darin Hobbs (MSc student)

Hazra Imran (Postdoc)

Stephen Kladich (MSc student & RA)

Jeff Kurcz (RA)

Renan Henrique Lima (undergrad. student)

Herbert Molenda (MSc student)

Abiodun Ojo (MSc student)

Kevin Saito (RA)

Mohamed Thaha (undergrad. student)

Richard Tortorella (MSc student & RA)

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

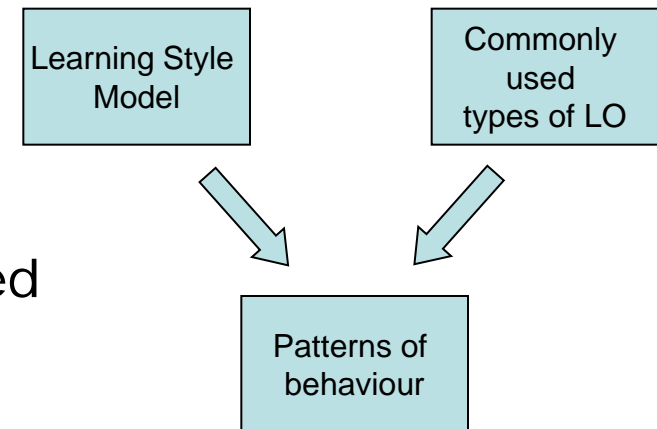
Felder-Silverman Learning Style Model

- 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

Active/Reflective	Sensing/Intuitive	Visual/Verbal	Sequential/Global
selfass_visit (+)	ques_detail (+)	forum_visit (-)	ques_detail (+)
exercise_visit (+)	ques_facts (+)	forum_stay (-)	ques_overview (-)
exercise_stay (+)	ques_concepts (-)	forum_post (-)	ques_interpret (-)
example_stay (-)	selfass_visit (+)	ques_graphics (+)	ques_develop (-)
content_visit (-)	selfass_result_duration (+)	ques_text (-)	outline_visit (-)
content_stay (-)	selfass_duration (+)	content_visit (-)	outline_stay (-)
outline_stay (-)	exercise_visit (+)		navigation_skip (-)
selfass_duration (-)	ques_rev_later (+)		overview_visit (-)
selfass_result_duration (-)	ques_develop (-)		overview_stay (-)
selfass_twice_wrong (+)	example_visit (+)		
forum_visit (-)	example_stay (+)		
forum_post (+)	content_visit (-)		
	content_stay (-)		

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

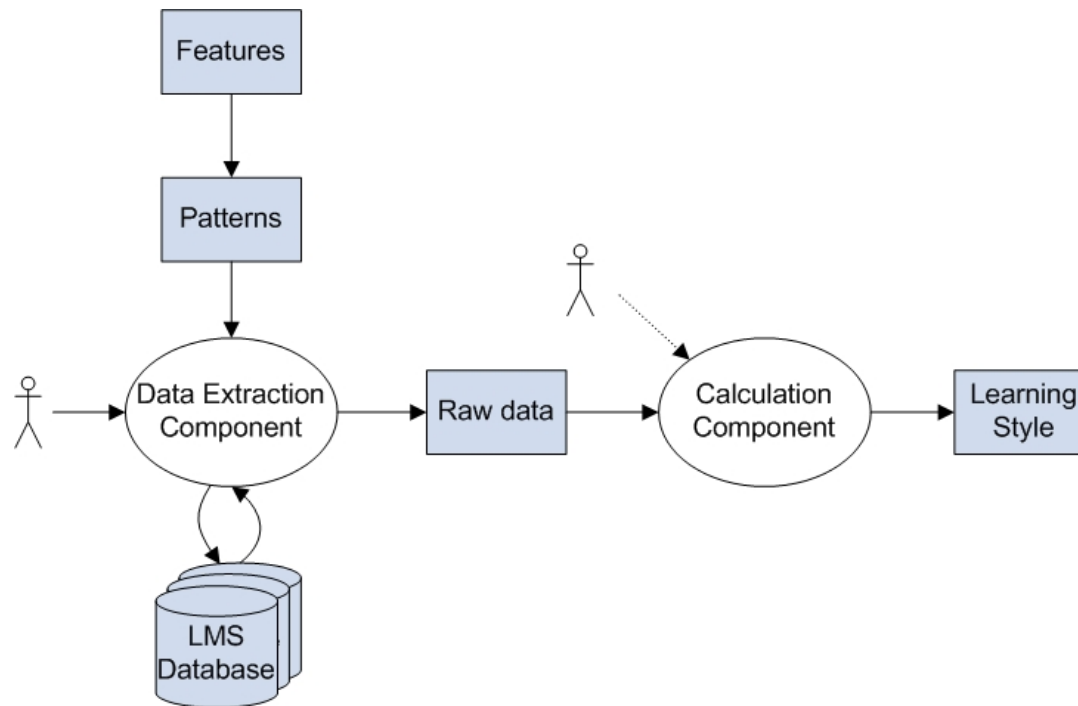
- Results

	act/ref	sen/int	vis/ver	seq/glo
comparison between ILS and automatic approach	79.33%	77.33%	76.67%	73.33%

→ 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

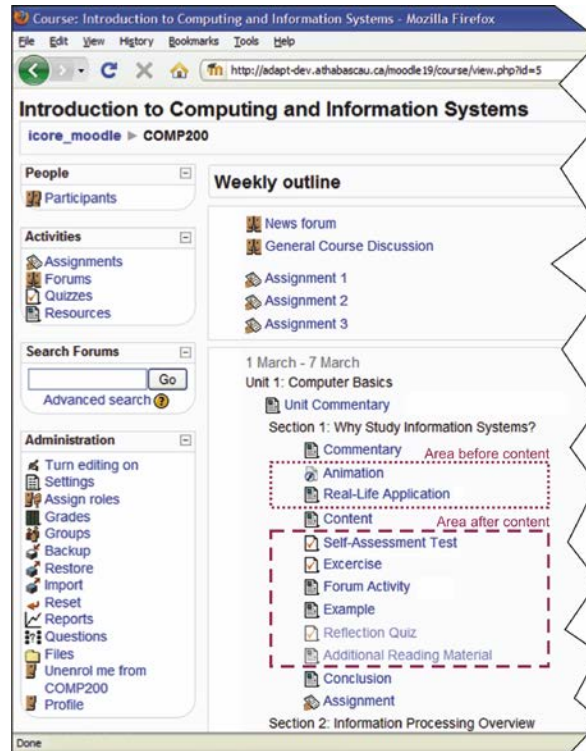
- Develop a mechanism that enables learning systems to automatically generate adaptive courses

- 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

Demo ...



Course: Introduction to Computing and Information Systems - Mozilla Firefox

http://dept-dev.athabascau.ca/moodle19/course/view.php?id=5

Introduction to Computing and Information Systems

icore_moodle ► COMP200

People
Participants

Activities
Assignments
Forums
Quizzes
Resources

Search Forums
Go
Advanced search

Administration
Turn editing on
Settings
Assign roles
Grades
Groups
Backup
Restore
Import
Reset
Reports
Questions
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Unenrol me from COMP200
Profile

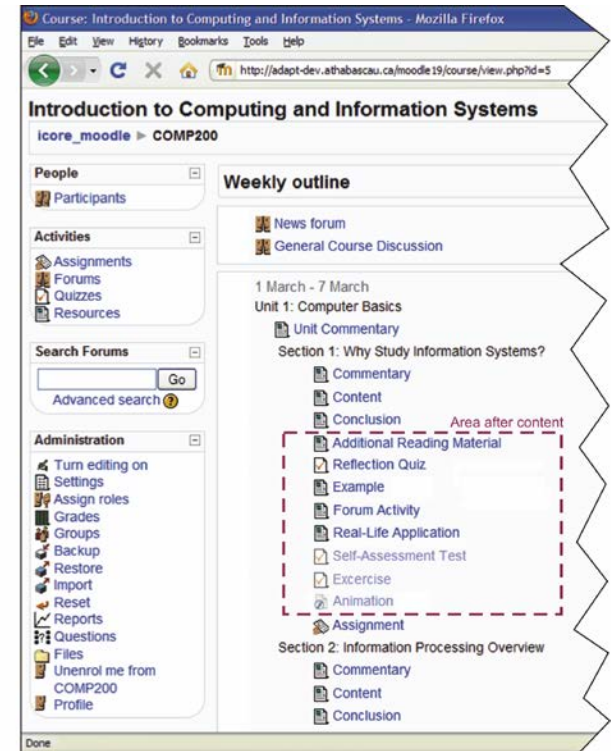
Weekly outline

- News forum
- General Course Discussion
- Assignment 1
- Assignment 2
- Assignment 3

1 March - 7 March
Unit 1: Computer Basics

- Unit Commentary
- Section 1: Why Study Information Systems?
 - Commentary Area before content
 - Animation
 - Real-Life Application
 - Content Area after content
 - Self-Assessment Test
 - Exercise
 - Forum Activity
 - Example
 - Reflection Quiz
 - Additional Reading Material
 - Conclusion
 - Assignment
- Section 2: Information Processing Overview

Done



Course: Introduction to Computing and Information Systems - Mozilla Firefox

http://adapt-dev.athabascau.ca/moodle19/course/view.php?id=5

Introduction to Computing and Information Systems

icore_moodle ► COMP200

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 - Commentary
 - Content
 - Conclusion

Done

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 ...

Course Analyzer

[Show Calculation Steps](#) | [Show Data Tables](#)

Analysis Settings

Select a Course:

Mode: General Cohort

Course Structure

- TEST505 for Testing
- [-] Section ID 45
 - [-] News Forum (Discussion Forum Activity)
 - [-] Introduction
 - [-] Application (Real-life Application)
 - [-] Material (Content)
 - [-] Media (Animation)
 - [-] Exercise
 - [-] Quiz1 (Self-Assessment Test)
 - [-] Practice (Exercise)
 - [-] Discussion (Discussion Forum Activity)
 - [-] EX (Example)
 - [-] Quiz2 (Reflection Quiz)
 - [-] Readings (Additional Reading Material)
 - [-] Summary (Conclusion)
 - [-] Section 1
 - [-] Section ID 48

Simulation Settings

Add LO (Drag and Drop)

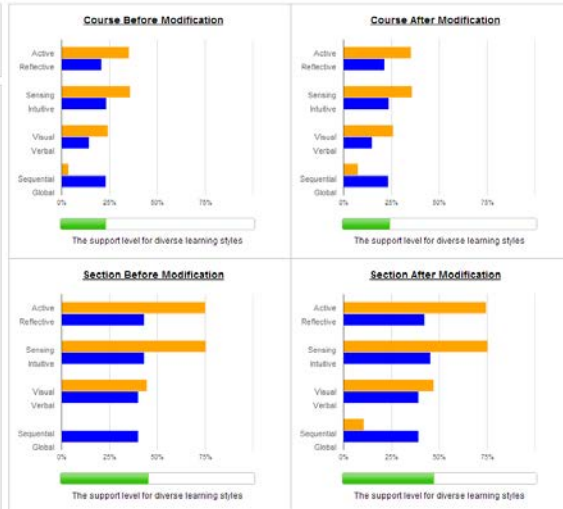
<input type="checkbox"/> Reflection Quiz	<input type="checkbox"/> Self-Assessment Test
<input type="checkbox"/> Discussion Forum Activity	<input type="checkbox"/> Additional Reading Material
<input type="checkbox"/> Animation	<input type="checkbox"/> Exercise
<input type="checkbox"/> Example	<input type="checkbox"/> Real-life Application

Remove LO (Drag and Drop)

Drop LO here to remove

Select the Course Suitable Learning Object Types

- RQ SAT DFA ARM Ani Exe Exa RLA



Analysis Settings

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Simulation Settings

Add LO (Drag and Drop)

<input type="checkbox"/> Reflection Quiz	<input type="checkbox"/> Self-Assessment Test
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Select the Course Suitable Learning Object Types

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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)

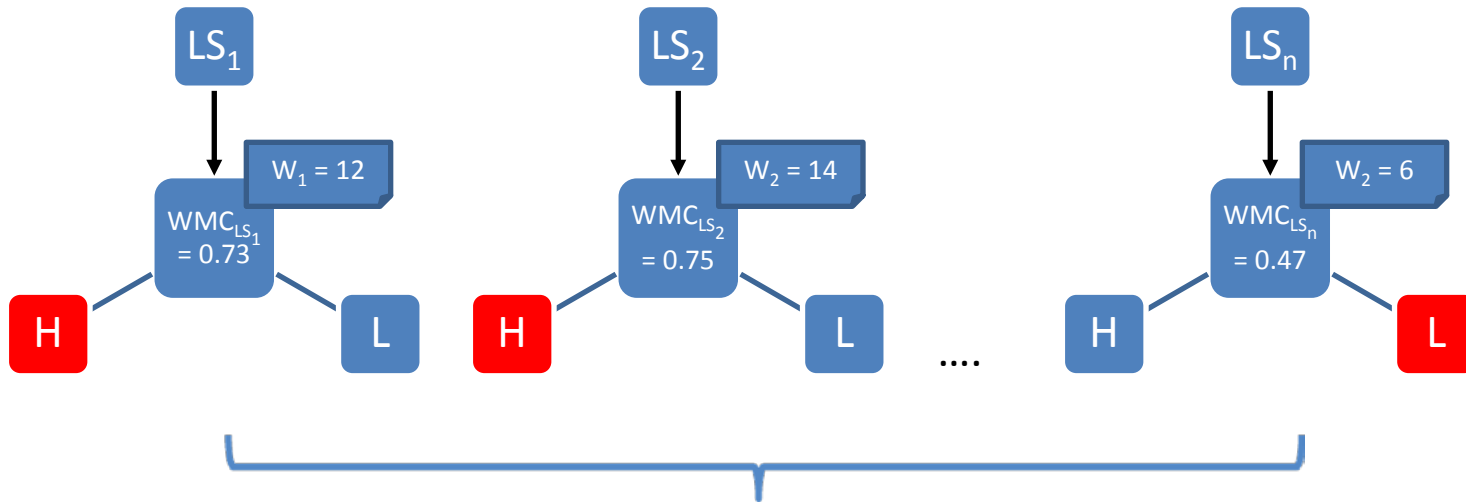
- WMC is an important trait for learning
- Learners with high WMC can remember almost double the amount of information than learners with low WMC
- However, typically learning systems do not consider this individual differences in WMC
- Research Aim:
 - Identify WMC automatically based on students' behaviour 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)



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

$$\left\{ \begin{array}{l} \text{HWMC if } WMC_{LS_i} > 0.5 \\ \text{LWMC if } WMC_{LS_i} < 0.5 \\ \text{Blanced if } WMC_{LS_i} = 0.5 \end{array} \right.$$

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

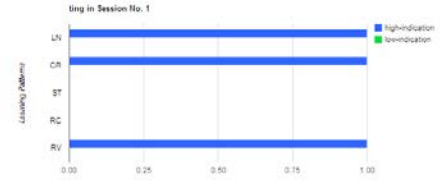

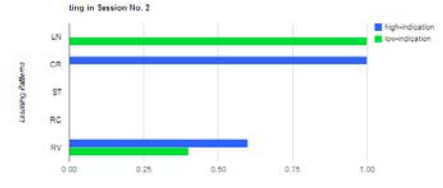

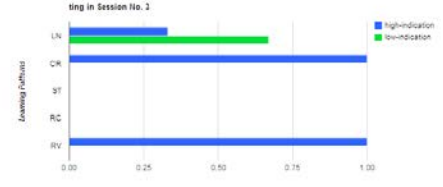

Demo

Demo ...

Start to WJMC Analysis Step 4 for mapping WJMC

Process completed
 student_wjmc Table has already been created

used = 2(WJMC_High (0.5~1), Blank(0.5) No Activation (Weight = 0), Low (0~0.5))

Learning Pattern Statistic		WJMC
 <p>WJMC: 0.83</p>		
 <p>WJMC: 0.48</p>		
 <p>WJMC: 0.67</p>		
WJMC summary		

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?

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

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



Sabine Graf

<http://sgraf.athabascau.ca>

sabineg@athabascau.ca