



# Athabasca University

FACULTY OF SCIENCE & TECHNOLOGY

School of Computing & Information Systems

## Adaptivity and Personalization in Educational Systems

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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
  - 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

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# Why Considering Cognitive Abilities in Learning Management Systems?

# 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 Working Memory Capacity?

- There are several cognitive traits/abilities that are highly relevant for learning (e.g., working memory capacity, inductive reasoning ability, associate learning skills, information processing speed, etc.)
- Working memory capacity (WMC) is a very important trait for learning
- WMC enables humans to keep active a limited amount of information for a very brief period of time.
- Miller (1956) found that people can remember  $7 \pm 2$  chunks of information.
- 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

- Aim of research:
  - 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



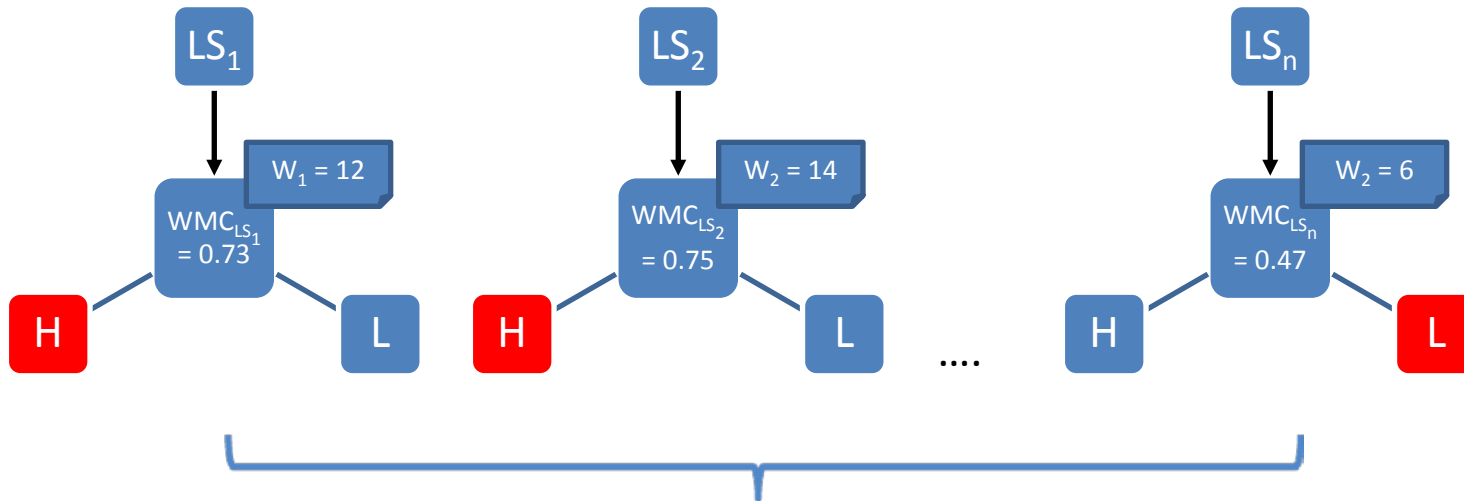
# How to Automatically Identify Cognitive Abilities in Learning Management Systems?

# 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)



$$\text{Total WMC} = \frac{\sum_{i=1}^n WMC_{LS_i} \times w_i}{\sum_{i=1}^n w_i} = \frac{0.73 \times 12 + 0.75 \times 14 + 0.47 \times 6}{12 + 14 + 6} = \frac{21.35}{31} = 0.69 \text{ (HWMC)}$$

$$\begin{cases} \text{HWMC if } WMC_{LS_i} > 0.5 \\ \text{LWMC if } WMC_{LS_i} < 0.5 \\ \text{Blanced if } WMC_{LS_i} = 0.5 \end{cases}$$

# Evaluation

- Study with 63 students
  - Asked students to perform Web-OSPAN task
  - Gathered data from students' behaviour in an online course
- Investigated difference between Web-OSPAN results and results from our approach
- Results:
  - Error rate: 0.191 (on a scale of 0 to 1)

# Evaluation

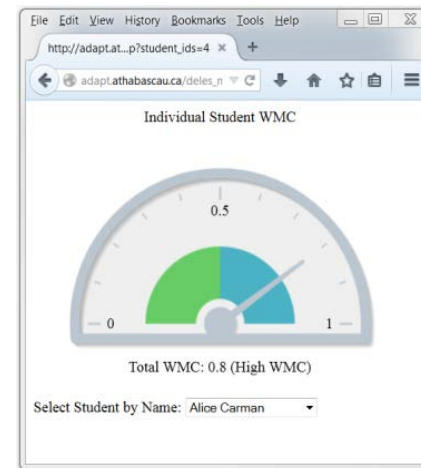
- Improvements through computational intelligence techniques
  - Use neural networks to classify behaviours
  - Use optimization algorithms (genetic algorithms, ant colony optimization, particle swarm optimization) to find out the weight of patterns
  - Results:

Approach	Error
Literature-based approach	0.1910
ANN	0.1376
GA	0.1484
ACS	0.1685
PSO	0.1654

# Visualization of WMC

- Once WMC is identified, we also want to use it
- Visualization of information to students/teachers
- Users can select a student and see their WMC

[Demo ...](#)



# 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“





# Visualization of Learning Style

- We also identify students' learning styles in a similar fashion and visualize this information to teachers
- Users can select a student and see their learning styles

[Demo ...](#)



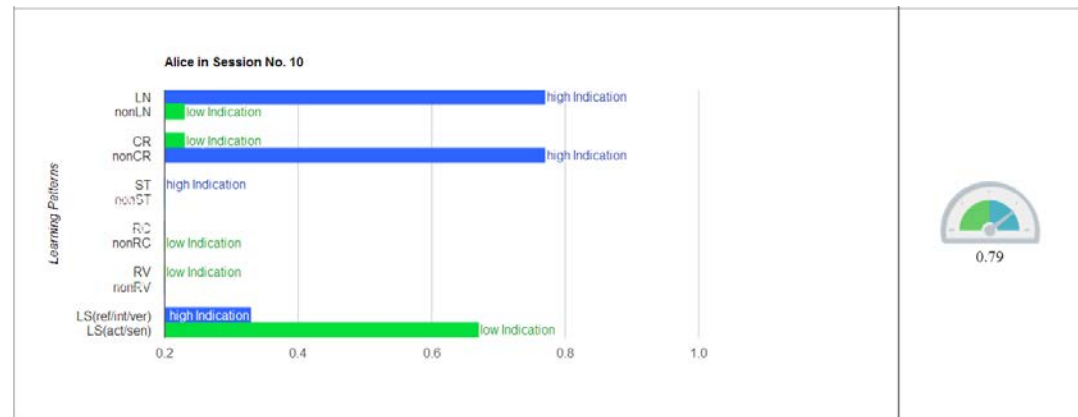
# **How to Provide Recommendations to Teachers based on Students' Working Memory Capacity?**

# Recommendations for Teachers based on Students' Cognitive Abilities

## ■ 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 ...



# **How to Provide Recommendations to Students based on their Working Memory Capacity?**

# Automatic Recommendations based on Students' Cognitive Abilities

## ■ Research aim

- Provide students with automatic recommendations to individually support their learning based on their WMC

## ■ Adaptive mechanism

- What recommendation shall the system show?
- When shall the system provide a recommendation?
- Which recommendation should be provided?
- Do students follow recommendations?

# What recommendations?

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

# When to show a recommendation?

- Show recommendation 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 show a recommendation?

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

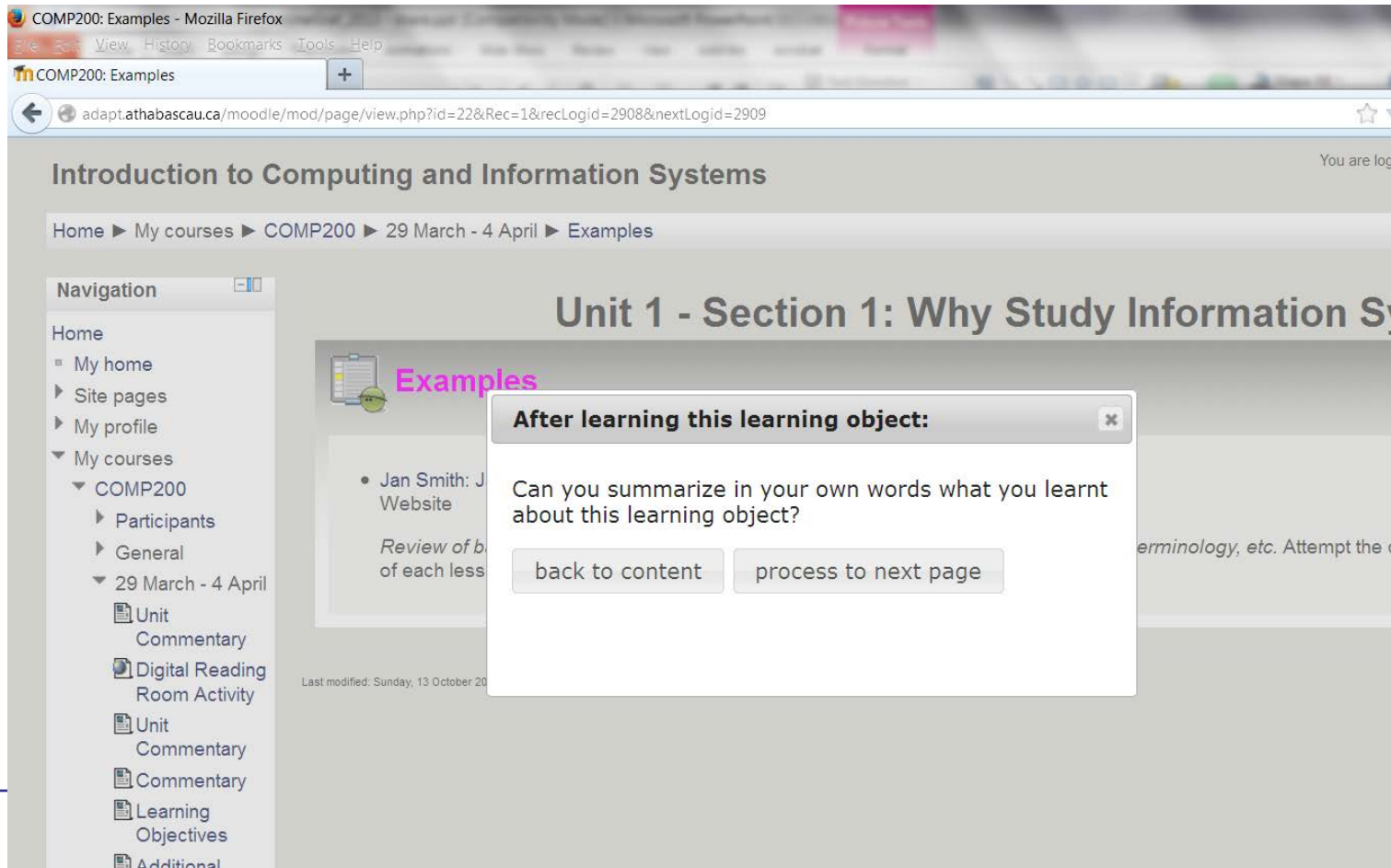


# When to present which recommendations?

- 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 a recommendation has been followed or not

# Demo

## Demo ...



The screenshot shows a web browser window displaying a Moodle course page. The browser title is "COMP200: Examples - Mozilla Firefox". The address bar shows the URL: `adapt.athabascau.ca/moodle/mod/page/view.php?id=22&Rec=1&recLogId=2908&nextLogId=2909`. The page content includes a navigation menu on the left, a breadcrumb trail: "Home > My courses > COMP200 > 29 March - 4 April > Examples", and a main heading: "Unit 1 - Section 1: Why Study Information Systems". A pink "Examples" label is overlaid on the page. A learning object is displayed with the text: "Jan Smith: J Website" and "Review of b of each less". A modal dialog box is open over the learning object, titled "After learning this learning object:", containing the question: "Can you summarize in your own words what you learnt about this learning object?". Below the question are two buttons: "back to content" and "process to next page".

# How to provide teachers with intelligent support based on learning styles?

# Why is there 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

- Focus on providing teachers with feedback on how well their courses work for students with different learning styles
- 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: TEST505 for Testing  
 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)  
 Practise (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)  

Reflection Quiz	Self-Assessment Test
Discussion Forum Activity	Additional Reading Material
Animation	Exercise
Example	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

#### Course Before Modification

The support level for diverse learners

#### Course After Modification

#### Section Before Modification

The support level for diverse learners

#### Section After Modification

### Analysis Settings

Select a Course: TEST505 for Testing  
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#### Course Before Modification

The support level for current learners' learning styles

#### Course After Modification

The support level for current learners' learning styles

#### Section Before Modification

The support level for current learners' learning styles

#### Section After Modification

The support level for current learners' learning styles

# Questions



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