SCIS
Athabasca University
SCHOOL OF COMPUTING & INFORMATION SYSTEMS

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

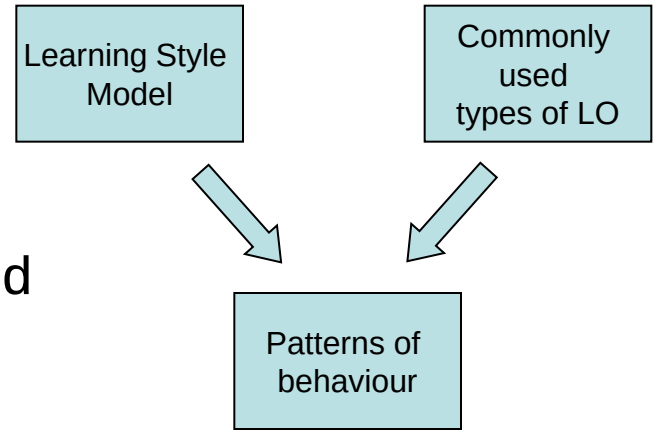
Felder-Silverman Learning Style Model

- 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

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

$$\text{Precision} = \frac{\sum_{i=1}^{n} Sim(LS_{predicted}, LS_{ILS})}{n}$$

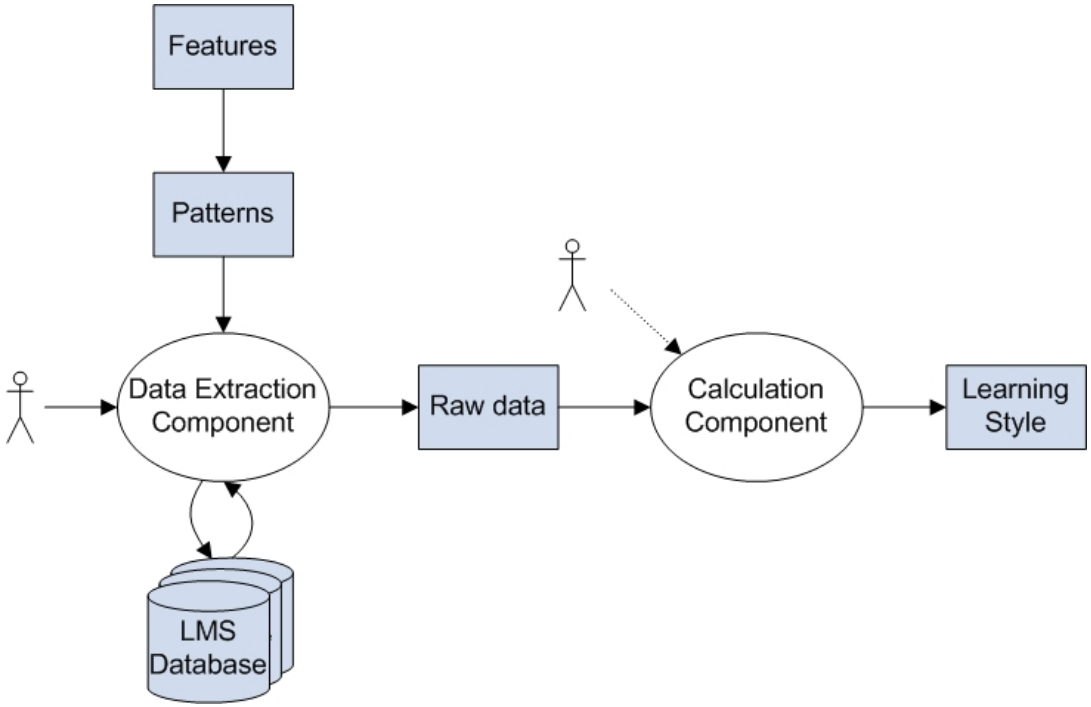
- Looking at the difference between results from ILS and automatic approach
- Results

	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

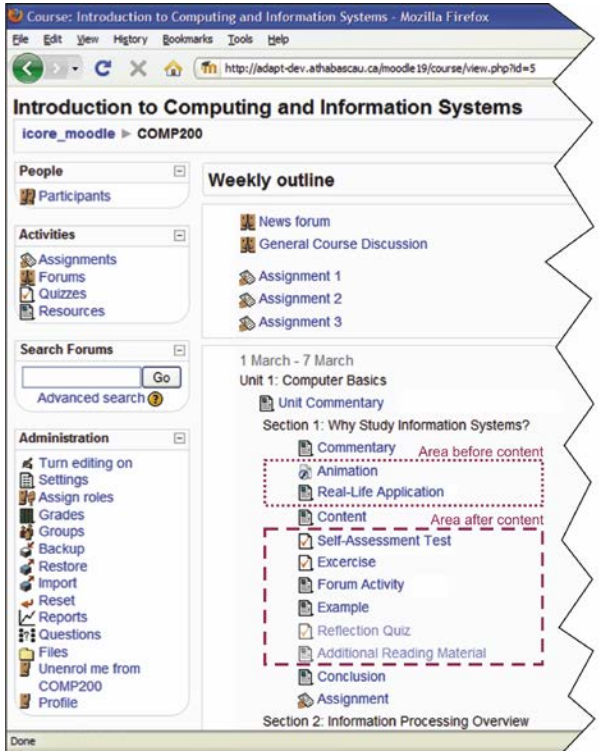
- Develop a mechanism that enables learning systems to automatically generate adaptive courses

- 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
File Edit View History Bookmarks Tools Help
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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
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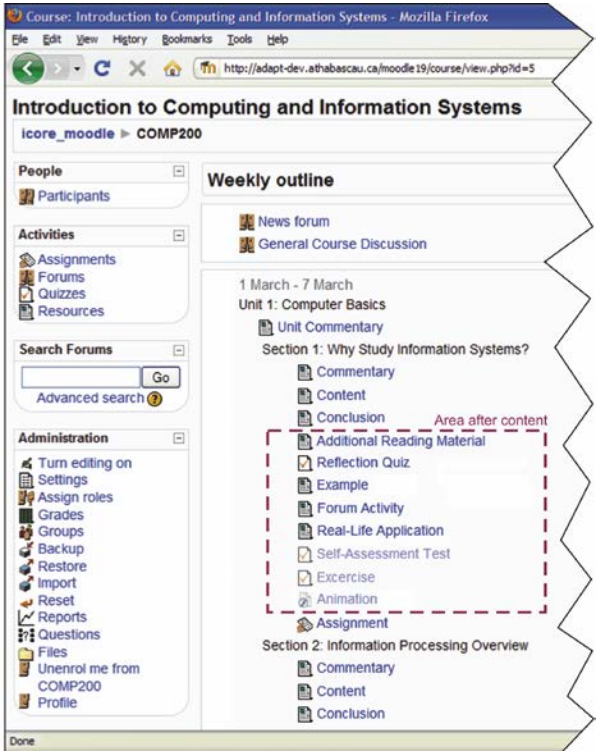
Weekly outline
News forum
General Course Discussion
Assignment 1
Assignment 2
Assignment 3
1 March - 7 March
Unit 1: Computer Basics
Unit Commentary
Section 1: Why Study Information Systems?
Commentary
Area before content
Animation
Real-Life Application
Content
Area after content
Self-Assessment Test
Excercise
Forum Activity
Example
Reflection Quiz
Additional Reading Material
Conclusion
Assignment
Section 2: Information Processing Overview
Done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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
Analysis Settings
Course Structure
Simulation Settings
Course Before Modification
Course After Modification
Section Before Modification
Section After Modification
The support level for diverse learning styles


Analysis Settings
Course Structure
Simulation Settings
Course Before Modification
Course After Modification
Section Before Modification
Section After Modification
The support level for current learners' learning styles

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)

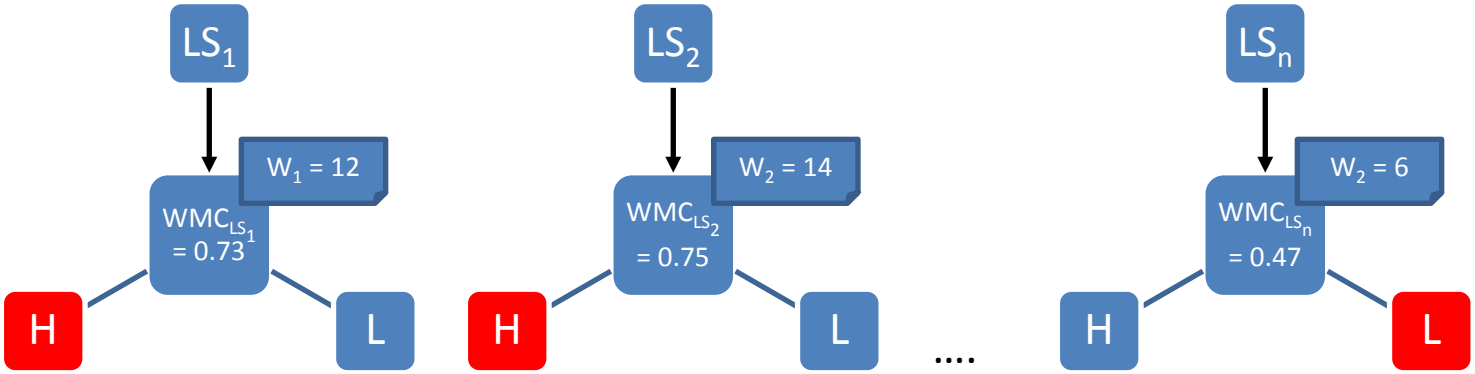
- WMC is an important trait for learning
- Learners with high WMC can remember almost double the amount of information than learners with low WMC
- However, typically learning systems do not consider this individual differences in WMC
- Research Aim:
  - Identify WMC automatically based on students'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



$$\text{Total WMC} = \frac{\sum_{i=1}^{n} WMC_{LS_i} \times w_i}{\sum_{i=1}^{n} w_i} = \frac{0.73\times11+0.75\times14+0.47\times6}{11+14+6} = \frac{21.35}{31} = 0.69 \text{ (HWMC)}$$

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

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

Demo ...


Start to WMC Analysis Step 4 for mapping WMC
Process completed
student_wmc Table has already been created
Learning Pattern Statistic
WMC
ting in Session No. 1
ting in Session No. 2
ting in Session No. 3
high-indication
low-indication
LN
CR
ST
RC
RV
0.00
0.25
0.50
0.75
1.00
WMC 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

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