



Athabasca University 

SCHOOL OF COMPUTING & INFORMATION SYSTEMS

# Adaptive and Intelligent Systems for Supporting 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
  - 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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  - **Cognitive traits**
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- Providing teachers with intelligent support
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  - **Easy access to educational log data**
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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

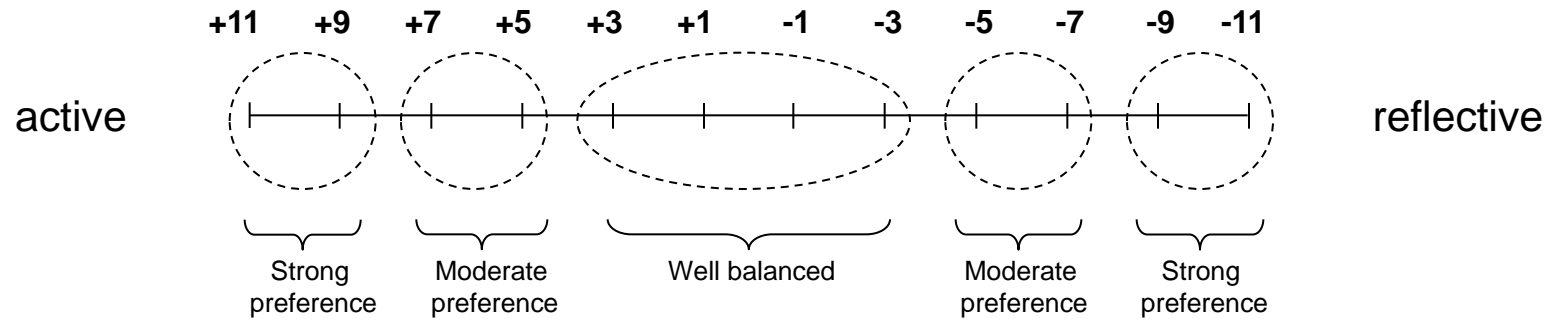
- Each learner has a preference on each of the dimensions
- Dimensions:
  - Active – Reflective  
learning by doing – learning by thinking things through  
group work – work alone
  - Sensing – Intuitive  
concrete material – abstract material  
more practical – more innovative and creative  
patient / 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:



→ Strong preference but no support → problems

# Felder-Silverman Learning Style Model

## ■ 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  $\leftrightarrow$  Scale)
- Represents also balanced preferences
- Describes tendencies
- Domain-independent
- Are “flexible-stable” over time

# **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

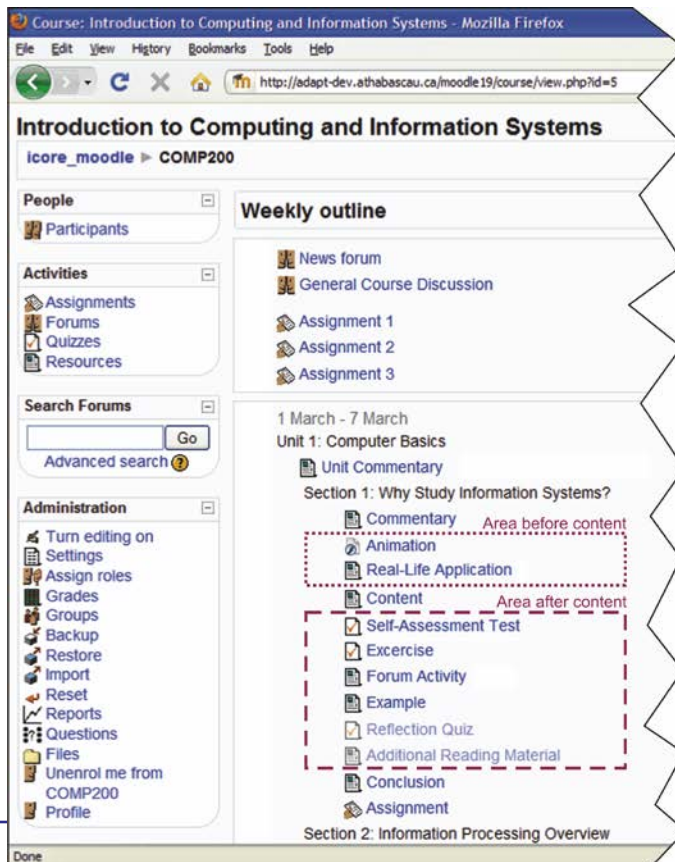
[Ting-Wen Chang, Jeff Kurcz]

# 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)

# Demo

## Demo ...



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

**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  
Files  
Unenrol me from COMP200  
Profile

#### Weekly outline

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

1 March - 7 March

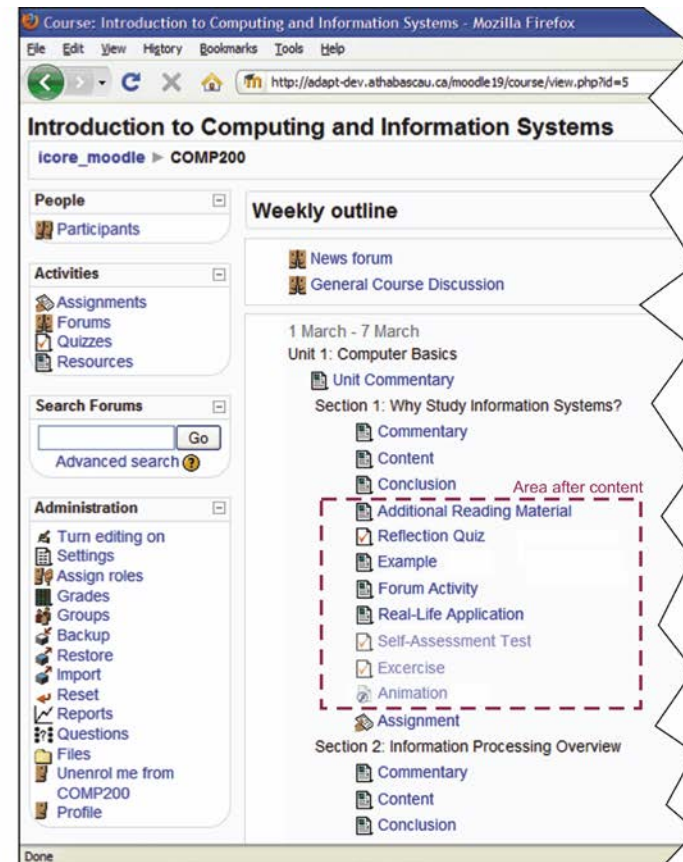
Unit 1: Computer Basics

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



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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#### Weekly outline

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Unit 1: Computer Basics

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- Commentary
- Content
- Conclusion Area after content
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- Animation
- Assignment

Section 2: Information Processing Overview

- Commentary
- Content
- Conclusion

# 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

# Why Considering Cognitive Abilities in Learning Management Systems?



# 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

# Automatic Recommendations based on Students' Cognitive Abilities

- However, typically learning systems do not consider this individual differences in WMC
- 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?

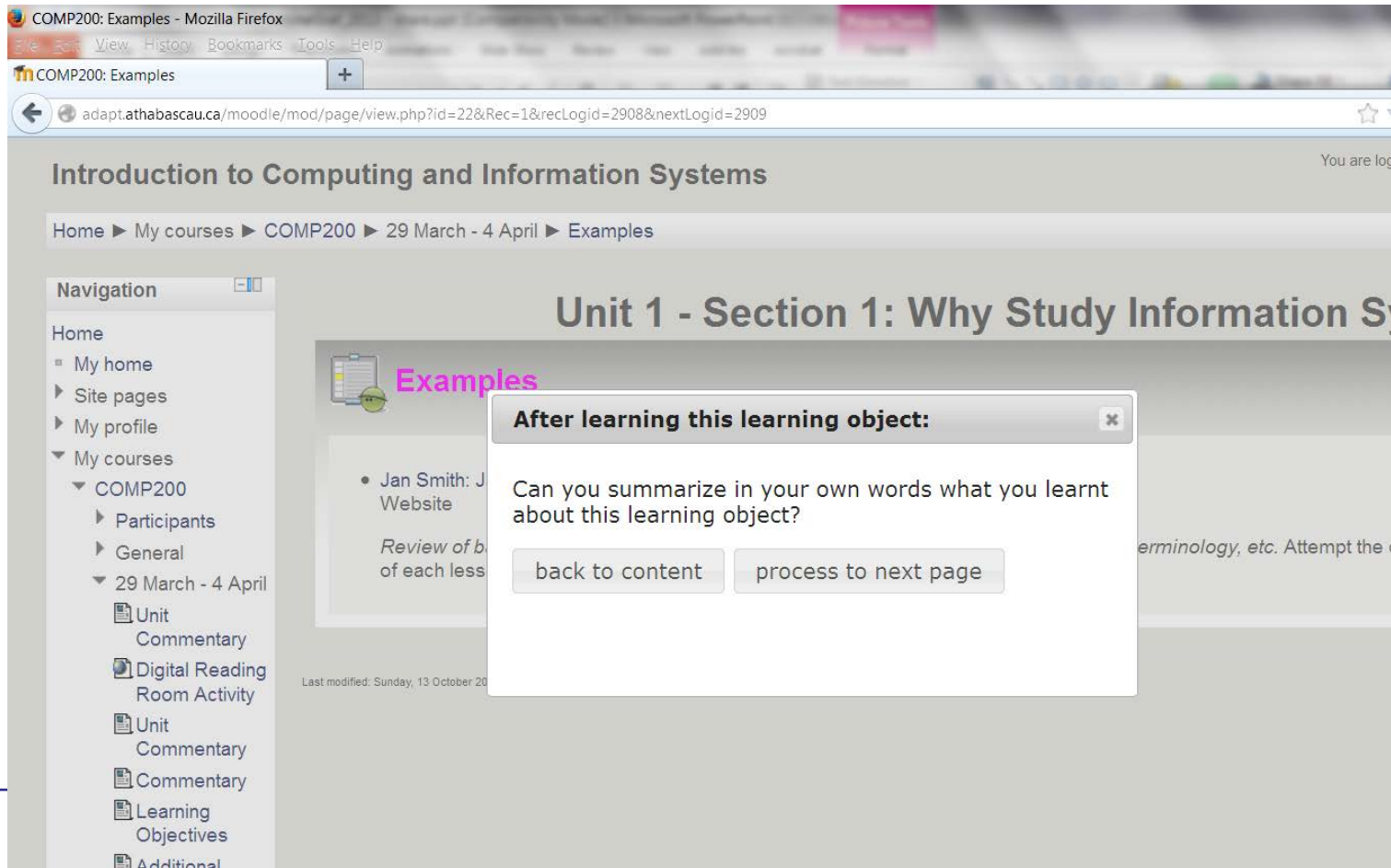
| No. | Asking the student to  | When<br>(before/after<br>learning) | Method                          |
|-----|--|------------------------------------|---------------------------------|
| R1  | <b>take notes</b> when he/she learns a learning object   | before                             | probability-based               |
| R2  | <b>request help</b> if he/she have any question by posting or asking teachers about this learning object | after                              | probability-based<br>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<br>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 ...



COMP200: Examples - Mozilla Firefox

COMP200: Examples

adapt.athabasca.ca/moodle/mod/page/view.php?id=22&Rec=1&recLogId=2908&nextLogId=2909

Introduction to Computing and Information Systems

Home ▶ My courses ▶ COMP200 ▶ 29 March - 4 April ▶ Examples

Navigation

- Home
  - My home
  - Site pages
  - My profile
- My courses
  - COMP200
    - Participants
    - General
    - 29 March - 4 April
      - Unit
        - Commentary
      - Digital Reading Room Activity
      - Unit
        - Commentary
      - Commentary
      - Learning Objectives
      - Additional

Unit 1 - Section 1: Why Study Information Systems

Examples

- Jan Smith: J Website

Review of b  
of each less

Last modified: Sunday, 13 October 20

terminology, etc. Attempt the c

You are log

**After learning this learning object:**

Can you summarize in your own words what you learnt about this learning object?

back to content    process to next page

# How to provide teachers with intelligent support?



# 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

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)  
 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)  
 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

**How to provide teachers with easy access to the huge amounts of educational log data?**

# Academic Analytics Tool (AAT)

- Learning Management Systems (LMSs) generate a lot of data
- Most LMS have some kind of statistics (e.g., last login of student, etc.)
- But such statistics only provide teachers with limited information
- However, to access the LMS database for getting full information, teachers and learning designers typically do not have skills to access/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 course designs

[Stephen Kladich, Jeremie Seanosky, Hazra Imran]

# Procedure

---

## Building a profile

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

# Wizard Start

Active Database: OldMoodle  
Selected Datasets: COMP200, COMP301

What you would like to do?

I want to create a new pattern from scratch.

**I want to create a new pattern from scratch.**

Select this if you want to create an entirely new Pattern

I want to create a new pattern from an existing pattern. Goes to select pattern screen then goes to Pattern Builder wizard with form prefilled.

**I want to create a new pattern from an existing pattern.**

Select this if you want to create a new Pattern, but start with an existing Pattern

I want to join two existing patterns. Goes to select pattern screen then goes to Pattern Builder wizard with form prefilled.

**I want to chain two existing patterns.**

Select this if you want to create a new Pattern, but as a combination of two existing Patterns

I want to perform an analysis on an existing pattern. Goes to select pattern screen then goes to perform analysis screen.

**I want to perform an analysis on an existing pattern.**

Select this if you want to see the SUM or Average or Count or Minimum value or Maximum value of an existing Pattern's results.



# Choose Concept

Selected outside wizard...here for reference.

Concepts listed dynamically based on concepts exposed via template (Concept table inner join concept mapping table where lms = active lms) Selecting concepts automatically populates the next tab - the attributes.

Pattern Result Pane will output the results of the pattern as it is being created - limit to top 10 rows.

SQL Pane is non-editable preview of the generated SQL. To be used as a debugging device for development or as a cool feature to show advanced users what SQL is being generated. This is updated dynamically as the user selects options in the wizard.

Active Database: OldMoodle  
Selected Datasets: COMP200, COMP301

**Choose Concepts** > **Choose Attributes** > **Add Limits** > **Define Sorting** > **Save**

What concepts you are interested in?

- Course**
- Forum**
- Quiz**
- Student**

Choose Attributes >>

**Pattern Result (top 10 rows only)**

| Column 1  | Column 2  |
|-----------|-----------|
| Content 1 | Content 2 |
| Content 3 | Content 4 |

**SQL Pane** [Copy](#)

```
SELECT
FROM blah, blah
WHERE
```

# Choose Concept Attributes

Concepts attributes listed dynamically based on concepts selected in previous step AND via template (Concept table inner join concept mapping table where lms = active database)

Pattern Result Pane will output the results of the pattern as it is being created - limit to top 10 rows.

SQL Pane is non-editable preview of the generated SQL. To be used as a debugging device for development or as a cool feature to show advanced users what SQL is being generated. This is updated dynamically as the user selects options in the wizard.

Active Database: OldMoodle  
Selected Datasets: COMP200, COMP301

[Choose Concepts](#) > [Choose Attributes](#) > [Add Limits](#) > [Define Sorting](#) > [Save](#)

What concept attributes you are interested in?

**Course**

- Course Name
- Course Open Date
- ...

**Student**

- Student Name

<< Choose Concepts    Add Filters >>

**Pattern Result (top 10 rows only)**

| Course Name | Course Open Date | ... | Course Duration | Student Name    |
|-------------|------------------|-----|-----------------|-----------------|
| COMP 200    | Sept 1 2012      | 111 | 45              | Sabine Graf     |
| COMP 200    | Sept 1 2012      | 123 | 45              | Stephen Klädich |
| COMP301     | Oct 12, 2012     | 123 | 90              | Kinshuk         |

SQL Pane [Copy](#)

```
SELECT blah, blah
FROM blah, blah
```

# Add Limits

At this point the concepts are listed along with filter types based on the data type of the attribute text --> = OR LIKE (for wildchar match)  
date --> range where if only one value is entered then it is the lower or upper bound, also equals (but not to time level)  
number --> range where if only one value is entered then it is the lower or upper bound

Filter options get set only when filter radio button selected...either 1 or 2 text boxes depending on data type and filter type  
Will have to validate data based on data type of attribute.

Active Database: OldMoodle  
Selected Datasets: COMP200, COMP301  
Choose Concepts > Choose Attributes > Add Limits > Define Sorting > Save

Do you want to define limits to the attributes?

| Attribute        | Limit Type   | Limit |
|------------------|--|-------|
| Course Name      | <input type="radio"/> Exactly <input type="radio"/> Like   |       |
| Course Open Date | <input type="radio"/> Earlier Than <input type="radio"/> Later Than <input type="radio"/> Between <input type="radio"/> Equals |       |
| ...              | <input checked="" type="radio"/> Equals <input type="radio"/> Between  | 123   |
| Course Duration  | <input type="radio"/> Equals <input type="radio"/> Between   |       |
| Student Name     | <input type="radio"/> Exactly <input type="radio"/> Like   |       |

I want ALL of the limits I define to apply to this pattern (narrows results)  
OR  
I want AT LEAST ONE limit to apply to this pattern (expands results)

ALL  At Least One

<< Choose Attributes Define Sorting >>

**Pattern Result (top 10 rows only)**

| Course Name | Course Open Date | ... | Course Duration | Student Name    |
|-------------|------------------|-----|-----------------|-----------------|
| COMP 200    | Sept 1 2012      | 123 | 45              | Stephen Kladich |
| COMP301     | Oct 12, 2012     | 123 | 90              | Kinshuk         |

SQL Pane [Copy](#)

```
SELECT blah, blah
FROM blah, blah
WHERE blah = 123
```

# Save

User will click Finish to save the pattern and go to the pattern management screen.  
User has option to make pattern usable (but not editable) by others.  
Pattern will be stored and can be chained/edited later.  
Will do check that no other pattern has same name prior to save.

Active Database: OldMoodle  
Selected Datasets: COMP200, COMP301  
Choose Concepts > Choose Attributes > Add Limits > Define Sorting > **Save**

What would you like to name your pattern?

Pattern Name (\*)  (50 chars max)  
Pattern Description  (200 chars max)

Pattern usable by others

\* Required

<< Define Sorting **Finish**

**Pattern Result (top 10 rows only)**

| Course Name | Course Open Date | ... | Course Duration | Student Name    |
|-------------|------------------|-----|-----------------|-----------------|
| COMP 200    | Sept 1 2012      | 123 | 45              | Stephen Kladich |
| COMP301     | Oct 12, 2012     | 123 | 90              | Kinshuk         |

SQL Pane [Copy](#)

```
SELECT blah, blah, MAX(Course Duration) as "Longest Course"
FROM blah, blah
WHERE blah = 123
GROUP BY Course Duration
ORDER BY blah
```

# Select Pattern

Active Database: OldMoodle  
Selected Datasets: COMP200, COMP301

Select what you patterns you would like to work with.

Available Patterns

- Pattern One**
- Pattern Two**
- Pattern Three**
- Pattern Four**
- Pattern Five**
- Pattern Six**
- Pattern Seven**

**OR**

Select what you pattern you would like to work with.

Available Patterns

- Pattern One**
- Pattern Two**
- Pattern Three**
- Pattern Four**
- Pattern Five**
- Pattern Six**
- Pattern Seven**

Depending on last choice, user can select one pattern (radio button) or two (checkbox) patterns.  
In the case of join two patterns will validate that only two checkboxes selected.  
Only patterns user created or are public will be displayed.

# Perform Analysis

- Selecting this checkbox means that only the computed column is in the result.
- Thus this part removes all other columns from the select list and
- Only those attributes that are of a numerical data type in the source pattern will be listed here. Calculations: COUNT/AVG /SUM/MIN/MAX
- Thus this part adds columns to the select list
- All of the pattern's Concepts listed here. GROUP BY clause defined here
- HAVING clause defined here...text based on type and attribute to analyze (user selected radio button and first drop down)
- User can then specify the Column Alias (Column header text) for the computed column Will have to validate that only alpha numerics are here.

Active Database: OldMoodle  
Selected Datasets: COMP200, COMP301

What type of analysis you wish to perform?

I only want to see a specific calculation

I would like to see the  COUNT  SUM  AVG  MIN  MAX

of  for every

Only show results with MAX Course Duration:

Less than  Greater than  Equal to this value:

I would like to refer to this column as:

**Pattern Result (top 20 rows only)**

| Course Name | Course Open Date | ... | Course Duration | Student Name    | Longest Course |
|-------------|------------------|-----|-----------------|-----------------|----------------|
| COMP 200    | Sept 1 2012      | 123 | 45              | Stephen Kladich | 90             |
| COMP 301    | Oct 12, 2012     | 123 | 90              | Kinshuk         | 90             |

**SQL Pane** [Copy](#)

```
SELECT blah, blah, MAX(Course Duration) as "Longest Course"
FROM blah, blah
WHERE blah = 123
GROUP BY Course Name
ORDER BY blah
```

# Questions



**Sabine Graf**

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