

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

**Dr. Sabine Graf**  
Associate Professor

<http://sgraf.athabascau.ca>  
[sabineg@athabascau.ca](mailto:sabineg@athabascau.ca)

## Research Team:

Muhammad Anwar (PhD student)  
Cecilia Ávila (PhD student)  
Silvia Margarita Baldiris Navarro (Postdoc)  
Mohammad Belghis-Zadeh (RA)  
Charles Jason Bernard (MSc student & RA)  
Edward da Cunha (MSc student)  
Kirstie Davidson (RA)  
Elinam Richmond Hini (MSc student & RA)  
Darin Hobbs (MSc student & RA)  
Hazra Imran (Postdoc)  
Zoran Jeremic (research programmer)  
Slobodan Jovicic (MSc student)  
Jeff Kurcz (MSc student and RA)  
Philippe Lachance (RA)  
Renan Henrique Lima (MSc student)  
Rose Simons (MSc student)  
Richard Tortorella (PhD student)  
Lanqin Zheng (Postdoc)

# 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

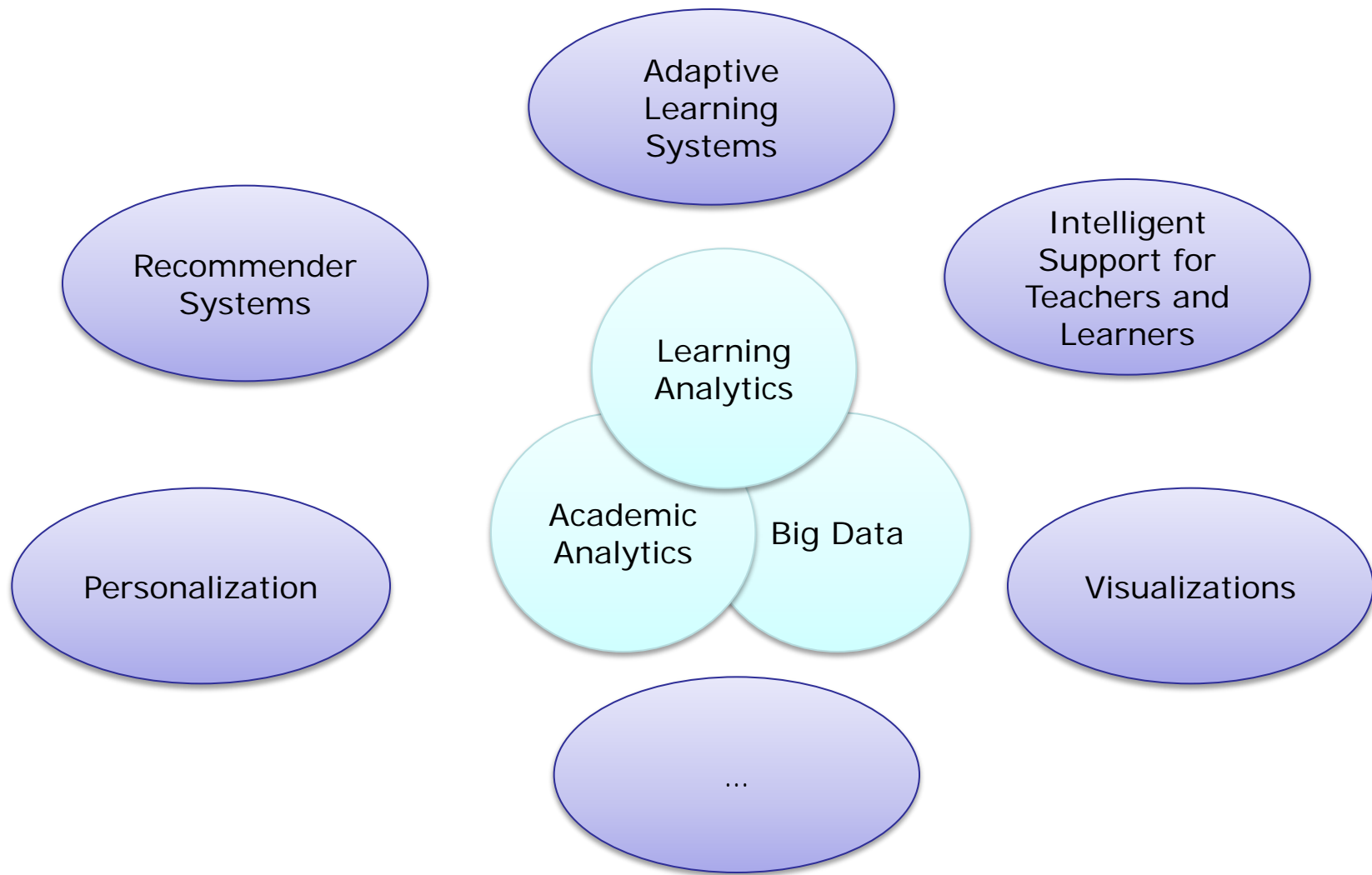
# Learning Analytics & Big Data

## ■ 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.)



# 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

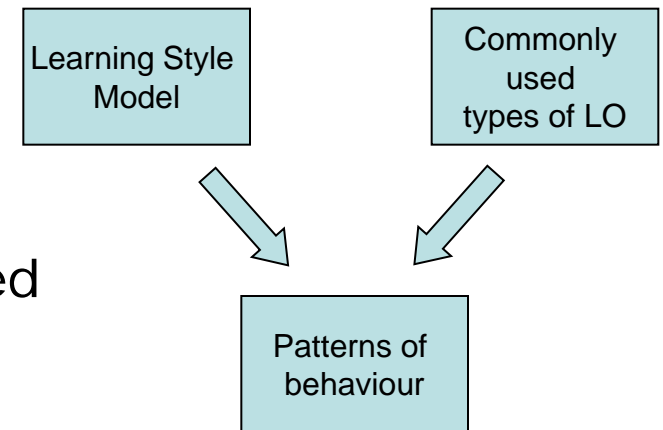
# Felder-Silverman Learning Style Model

- 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

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

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

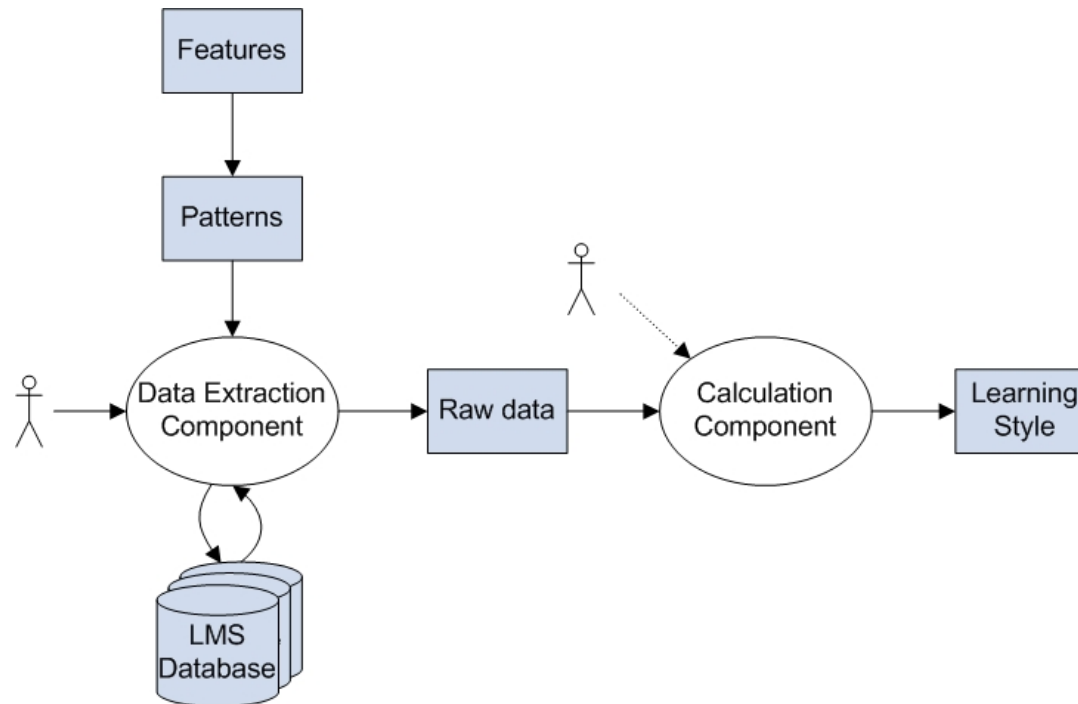
- Looking at the difference between results from ILS and automatic approach
- Results

	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



# Current work

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- 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)

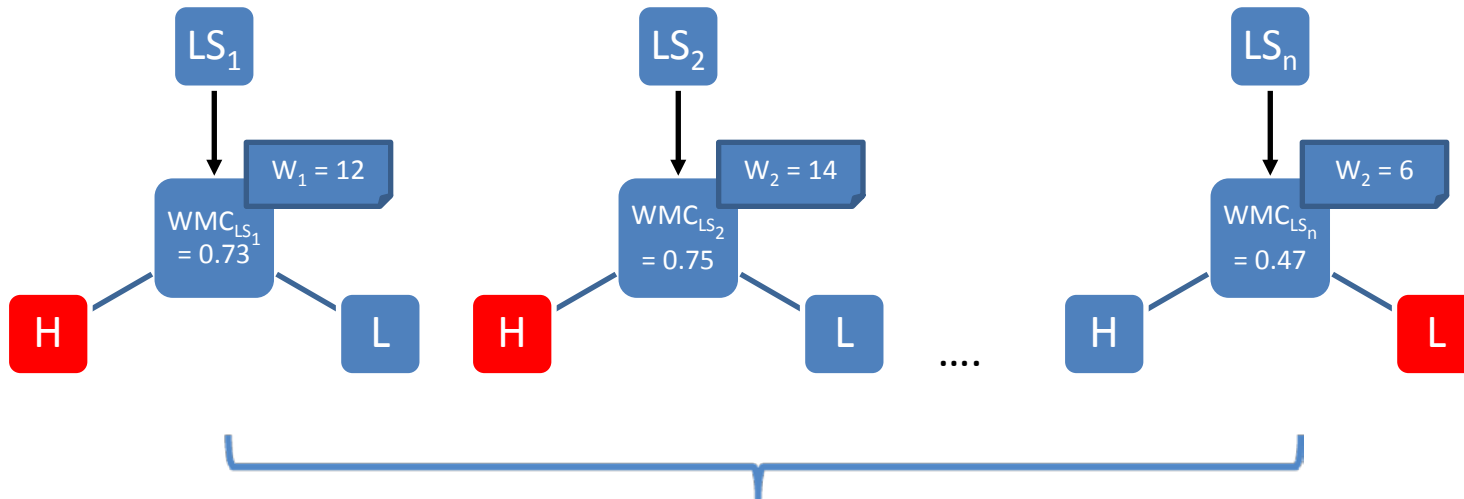
- WMC is an important trait for learning
- WMC enables the human brain to keep active a limited amount of information for a very brief period of time
- Learners with high WMC can remember almost double the amount of information than learners with low WMC
- However, typically learning systems do not consider 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

# 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)



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

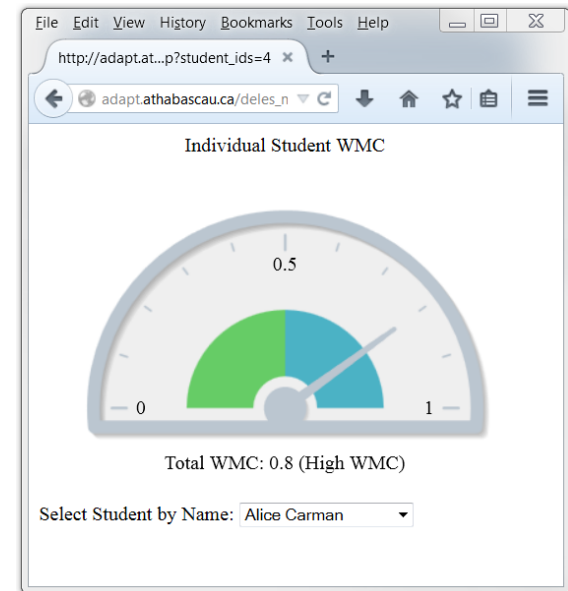
$$\begin{cases} \text{HWMC if } WMC_{LS_i} > 0.5 \\ \text{LWMC if } WMC_{LS_i} < 0.5 \\ \text{Blanced if } WMC_{LS_i} = 0.5 \end{cases}$$

# Evaluation

- Study with 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 ( $\chi^2 = 4.686, df = 1, p = .03$ )
- 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

[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

# Academic Analytics Tool (AAT)

- 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

# Procedure

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## Building a profile

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

# Demo

## Demo ...

**AAT - Academic Analytics Tool**

Help

This page lists all of your patterns in addition to any public patterns created by other users. Click the "Rename" link to rename a pattern, click "Delete" to delete a pattern, and click the pattern name itself to run the pattern and see its results.

List Patterns
Restart Wizard

### Step 4B -- Building the Analysis

What type of analysis do you wish to perform?

Analysis with one value as result  
 Analysis with one column as result

I would like to see the  COUNT  SUM  AVG  MIN  MAX of assignment final grade for every Learner

Only show results with **assignment final grade**:

Less than  Greater than  Equal to this value:

I would like to refer to this result as:

Analysis Name (\*):  (50 chars max)

Analysis Description:  (200 chars max)

Choose a Pattern
Perform Analysis
Save Analysis

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**AAT - Academic Analytics Tool**

Help

This page lists all of your patterns in addition to any public patterns created by other users. Click the "Rename" link to rename a pattern, click "Delete" to delete a pattern, and click the pattern name itself to run the pattern and see its results.

**i** Dataset has been successfully created/selected. You can now proceed with selecting/creating a pattern for the current profile.

Back
to Create or Choose Dataset(s)

### Step 4 -- Choose / edit a pattern or create a new one for profile "profile5"

Create New Pattern

Select All
Deselect All

Name	Description	Owner	Public	Operations
<input type="checkbox"/> forum1		Sabine Graf	No	Rename Edit Delete
<input type="checkbox"/> forum_analysis2		Sabine Graf	No	Rename Edit Delete
<input checked="" type="checkbox"/> pattern4		Sabine Graf	No	Rename Edit Delete

Continue
with Selected Patterns

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