SCIS

Athabasca University

SCHOOL OF COMPUTING & INFORMATION SYSTEMS

Ubiquitous Learning Analytics – Student/Context Modelling and Adacemic Analytics

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Adaptivity and Personalization

Mobile Learning

Pervasive Learning

Ubiquitous Learning

Student/Context Modelling

Sensor Technology

Ubiquitous Learning Analytics

Learning Analytics

Educational Data Mining

Learner Analytics

Sense Making

Academic Analytics

Visualization Techniques

Adaptivity and Personalization

Mobile Learning

Pervasive Learning

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Learning Analytics

Educational Data Mining

Learner Analytics

Sense Making

Academic Analytics

Visualization Techniques

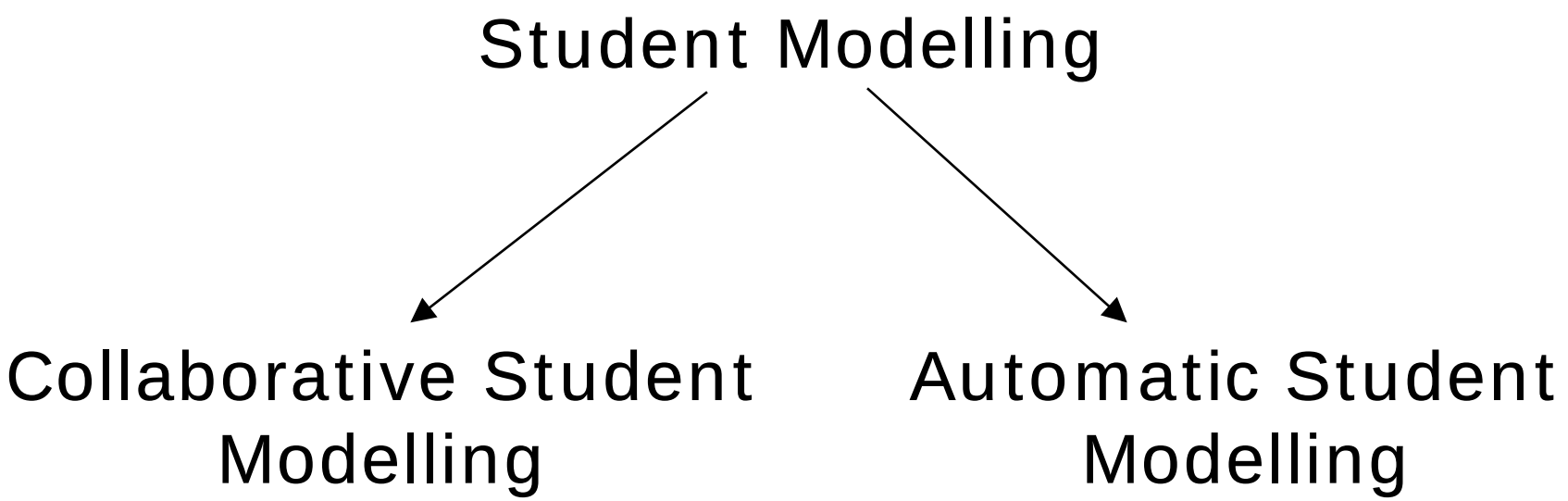
Student/Context Modelling

- Plays a critical role in ubiquitous learning systems
- A student model includes all information about a student that is relevant for providing adaptivity and personalization in an ubiquitous learning system
- Student modelling is the process of building and updating the student model
- A context model includes all information about a student's context that is relevant for providing adaptivity and personalization in an ubiquitous learning system
- Context modelling is the process of building and updating a context model

What data can be included in a student/context model?

- Knowledge
- Goals
- Motivational aspects
- Learning styles
- Cognitive abilities
- Meta-cognitive abilities
- Affective states
- Location
- Environmental context
- etc.

Student Modelling Approaches



Student Modelling Approaches

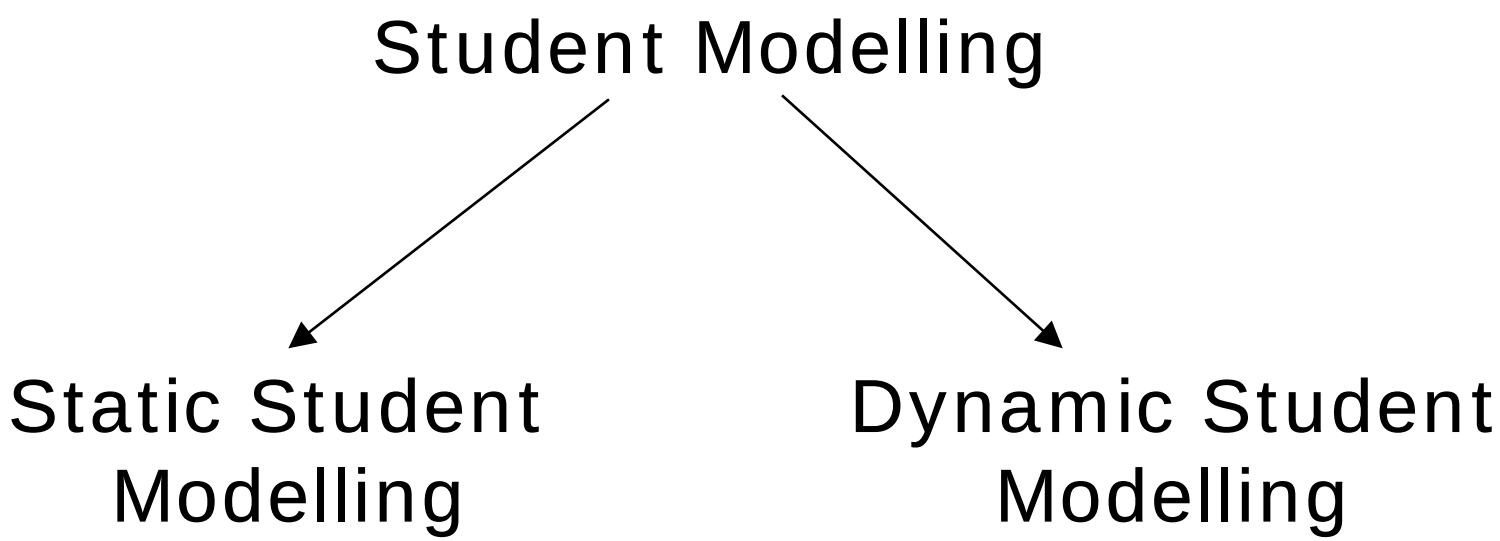
- Collaborative Student Modelling
  - Ask learner explicitly for information
  - Different approaches:
    - Using questions or questionnaires
      Challenges:
      - Reliability & validity of the instrument
      - Motivate students to fill it out reliably
      - Non-intentional influences
      - Static instrument

Student Modelling Approaches

Automatic student modelling

- Using automatically gathered data to identify students' situation, needs and characteristics
- Commonly used sources for data are sensors and user interactions
- Rather than asking a student, we use real data (e.g., What are students really doing in an online system? Where are students? etc.)
- Advantages:
  - Students have no additional effort
  - Uses information from a time span → higher tolerance
  - Allows dynamic updating of information
- Problem/Challenge:
  - Get enough reliable data to build a robust student model

Student Modelling Approaches



Student Modelling Approaches

- Static vs. Dynamic
  - Static: student model is built once
  - Dynamic: student model is frequently updated based on new data
- Advantages of Dynamic Student Modelling
  - dynamically building a student model by incrementally improving and fine-tuning the information in the student model in real-time
    → getting sooner a more accurate student model
  - consider exceptional behaviour of students
    → more accuracy due to considering exceptional behaviour
  - dynamically updating a student model by identifying and responding to changes in students' characteristics/situations over time
    → more accuracy due to considering changes

Student Modelling Approaches

Group activity:

	Collaborative	Automatic
Static	?	?
Dynamic	?	?

Automatic Identification of Learning Styles

How to automatically identify students' learning styles based on their behaviour?

- 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

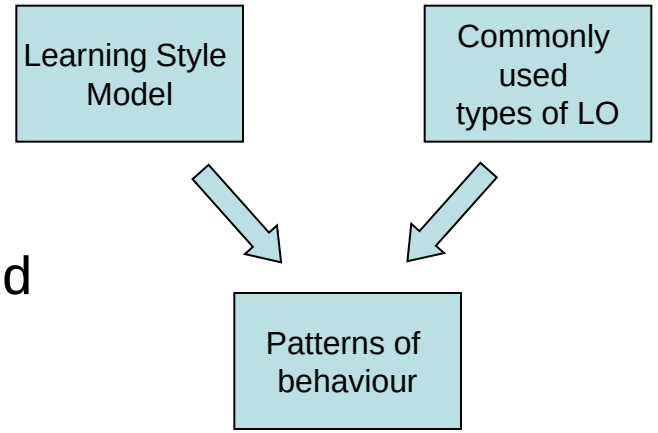
Felder-Silverman Learning Style Model

- 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

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

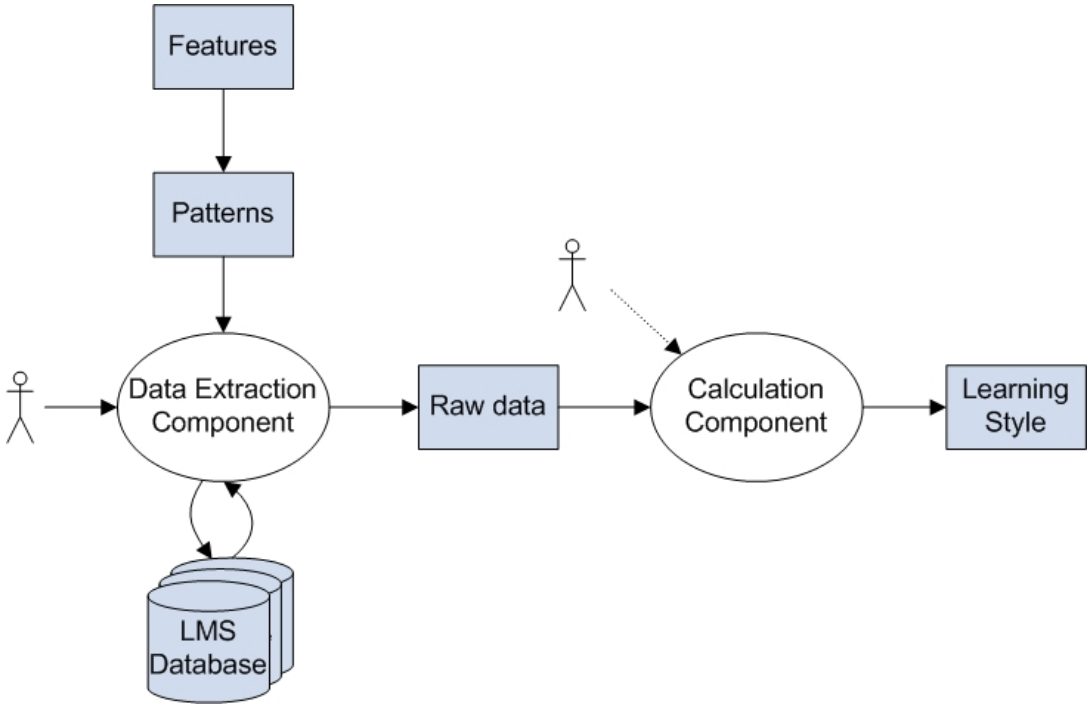
- Looking at the difference between results from ILS and automatic approach
- Results

	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



Automatic Identification of Working Memory Capacity (WMC)

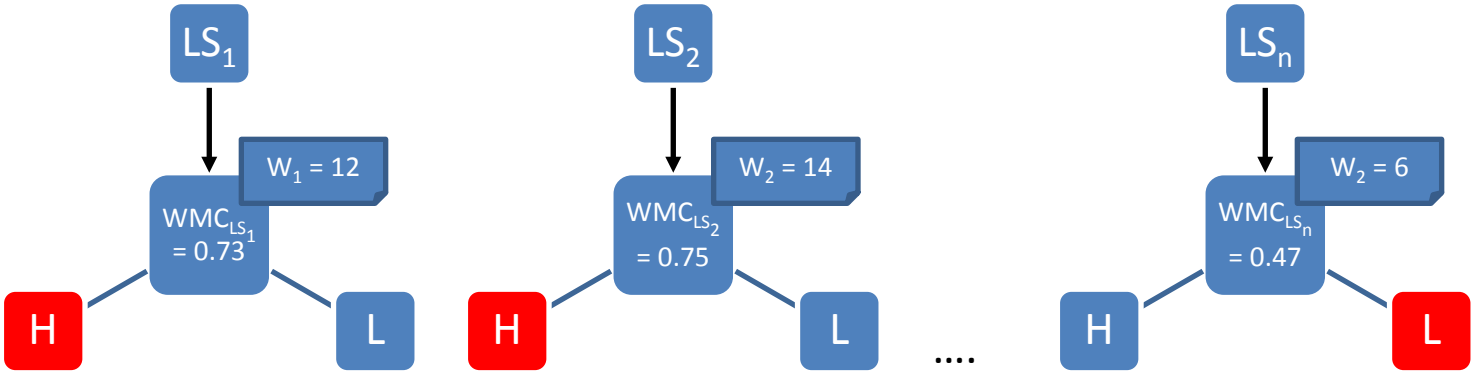
- WMC is an important trait for learning
- WMC enables the human brain to keep active a limited amount of information for a very brief period of time
- Learners with high WMC can remember almost double the amount of information than learners with low WMC
- However, typically learning systems do not consider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



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

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

Automatic Identification of Device Functionalities and Usage

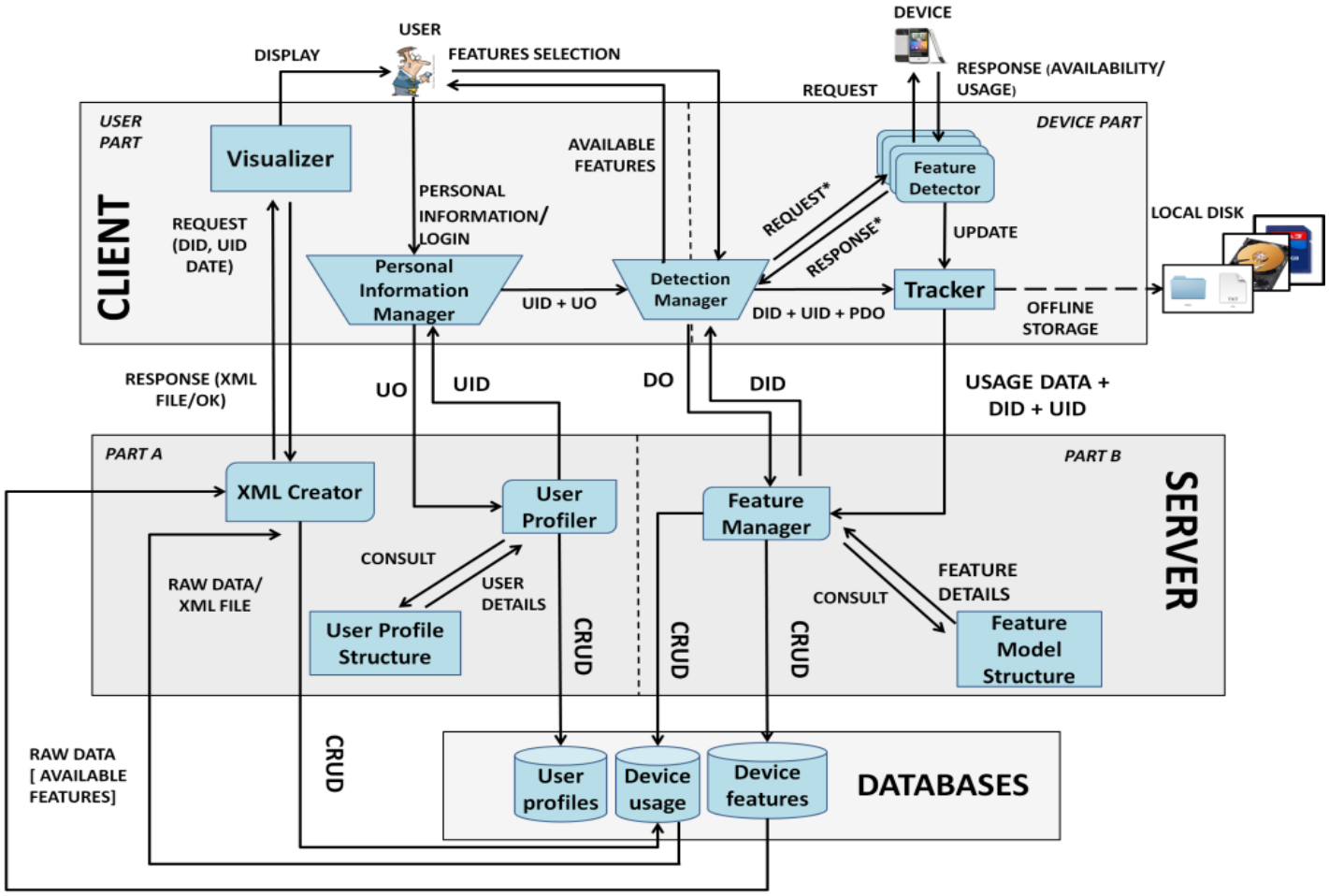
How to identify device functionalities and usage of such functionalities?

- General Aim and Benefits:
  - Approach should work for smartphones, tablets and desktop computers
  - Investigating how learners use their mobile devices for learning
  - Identifying learning strategies that are successful
  - Basis for adaptivity and personalization based on students' context

Features

Category	Feature name
Communication	Bluetooth
	Wi-Fi
	Telephony
	SMS
Location	GPS
	Network Location
Sensors	Camera
	Microphone
	Barometer
	Compass
	Gyroscope
	Light
	Proximity
	Accelerometer
Input	Soft Keyboard
	Hard Keyboard
	Touchscreen

Architecture



Legend:

REQUEST*: Detection Manager requests the device available features
RESPONSE*: Feature Detector(s) responses with the device available features
UO: User Object **DO:** Device Object **PDO:** Particular Device Object
UID: User ID **DID:** Device ID **CRUD:** Create, Update, Retrieve and Delete

Academic Analytics

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
    - ...

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:

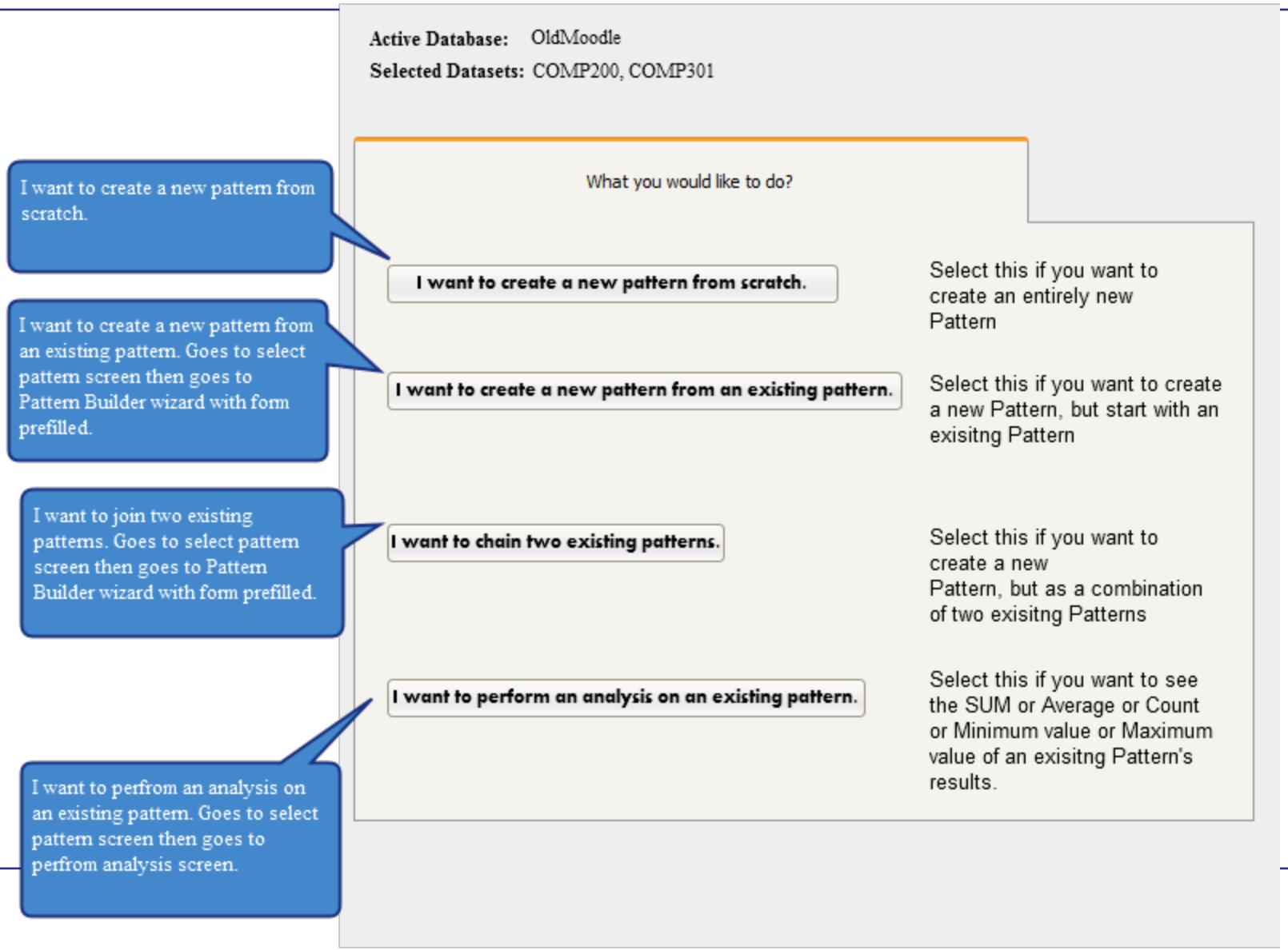
- Design, develop and evaluate a tool that provides users with easy access to complex educational log data
- Allow users to ask “questions” to the data
- Allow users to start with easy queries and then build upon them
- Work for different LMS
- Facilitate teachers’ learning about their teaching strategies and course designers’ learning about their learning designs

Procedure

Building a profile

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

Wizard Start



Choose Concept

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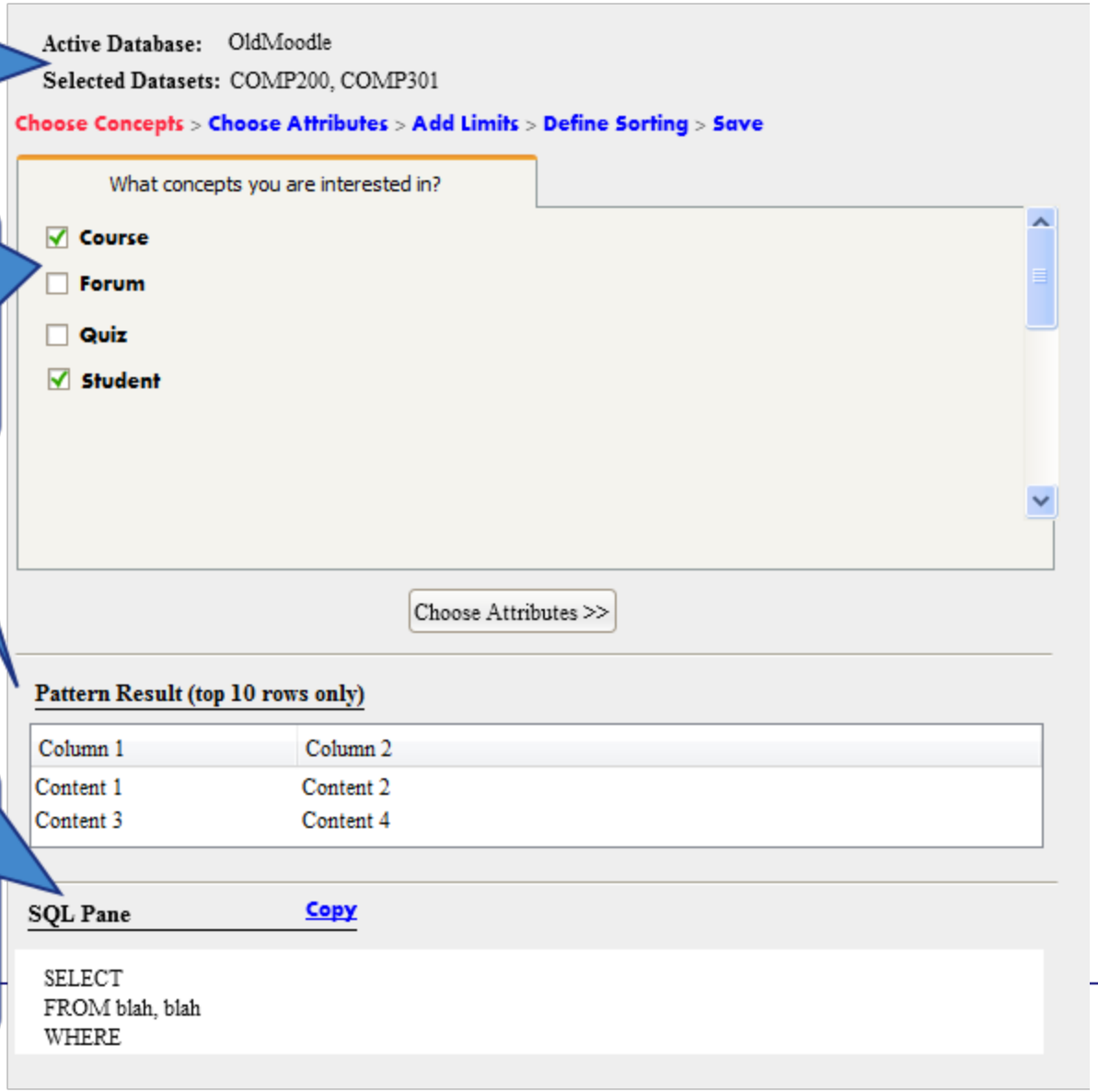
Selected outside wizaed...here for reference.

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.

Patter Result Pane will output the results of the patter 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 updaed dynamically as the user selects options in the wizard.



Choose Concept Attributes

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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)

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

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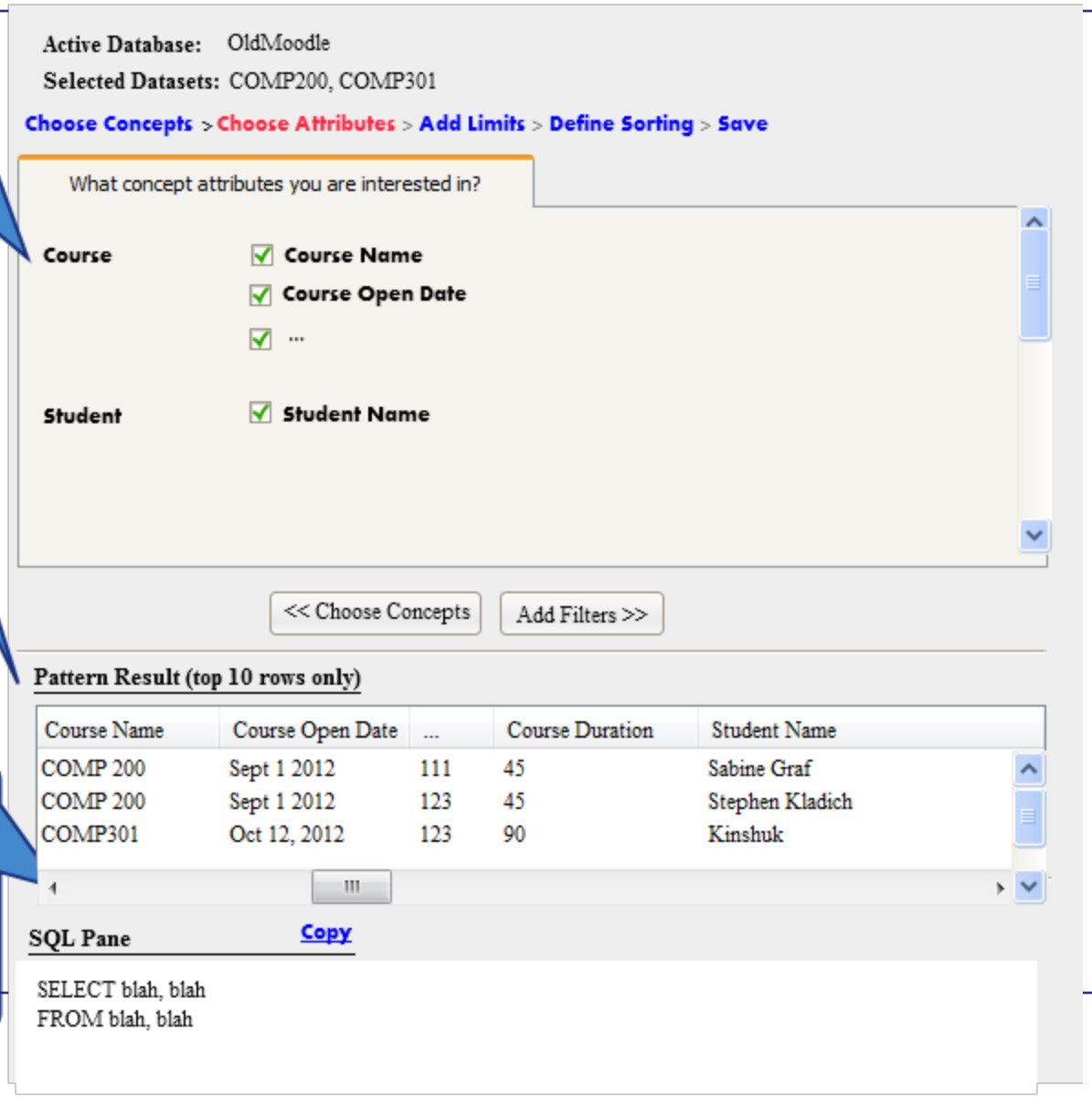
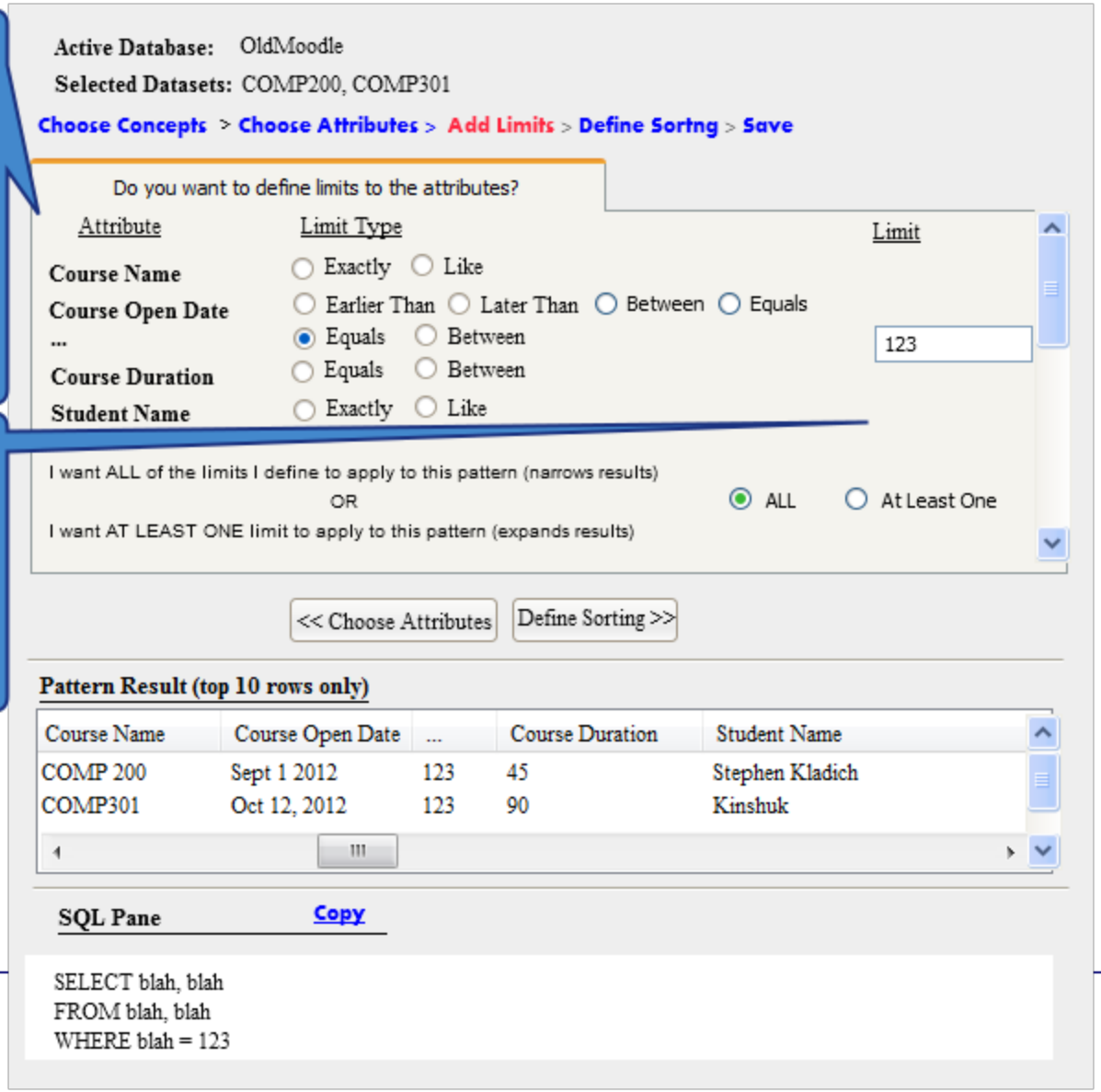


Add Limits

At this point the concepts are listed along with filter types based on the data type of the attribute
text --> = OR LIKE (for whildchard 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 depedning on data type and filter type
Will have to validate data based on data type of attribute.

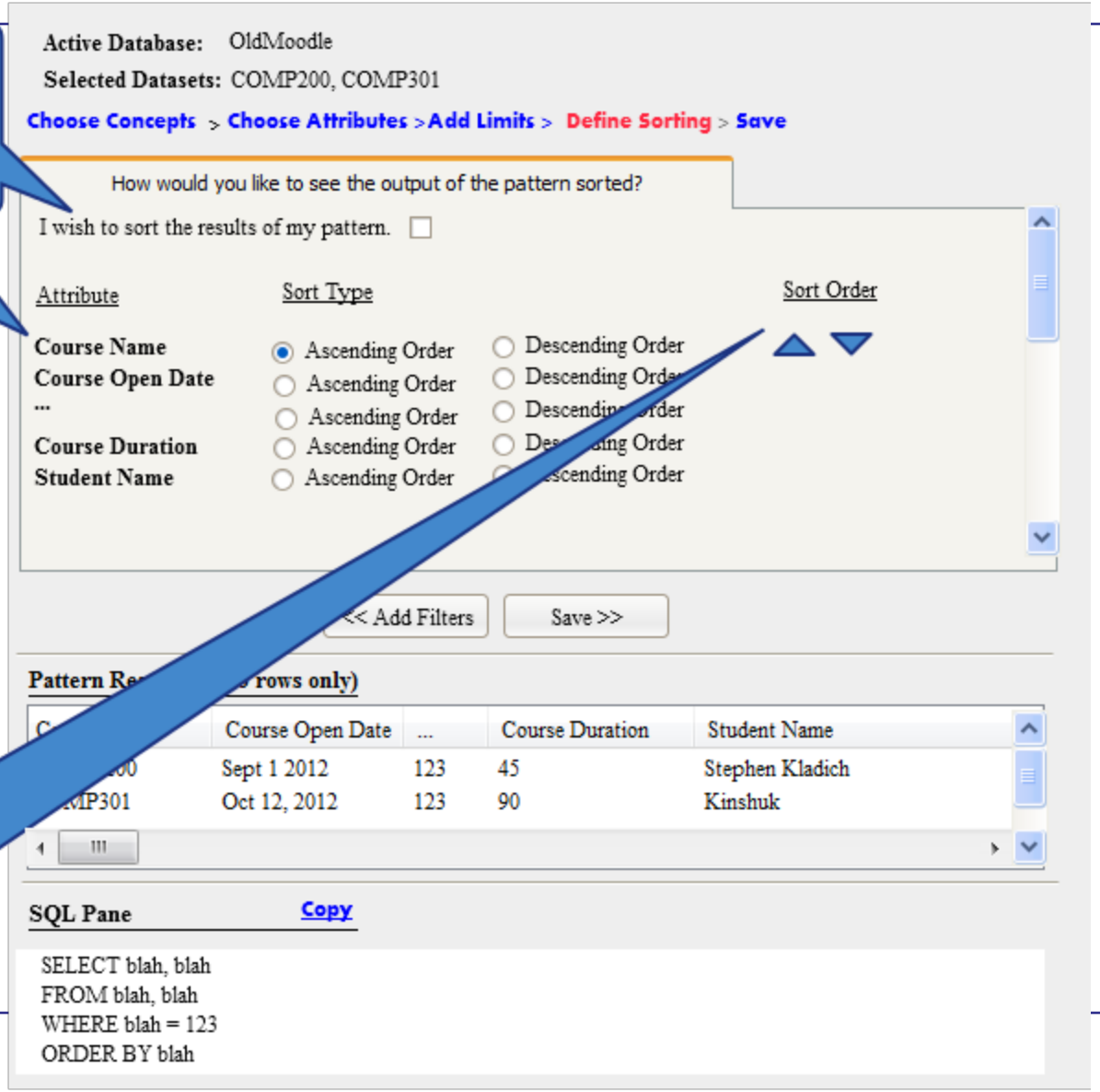


Define Sorting

By default sorting form elelments will be disabled until this is checked. Unchecking will reset this part of form (and hence reverthe SQLas well).

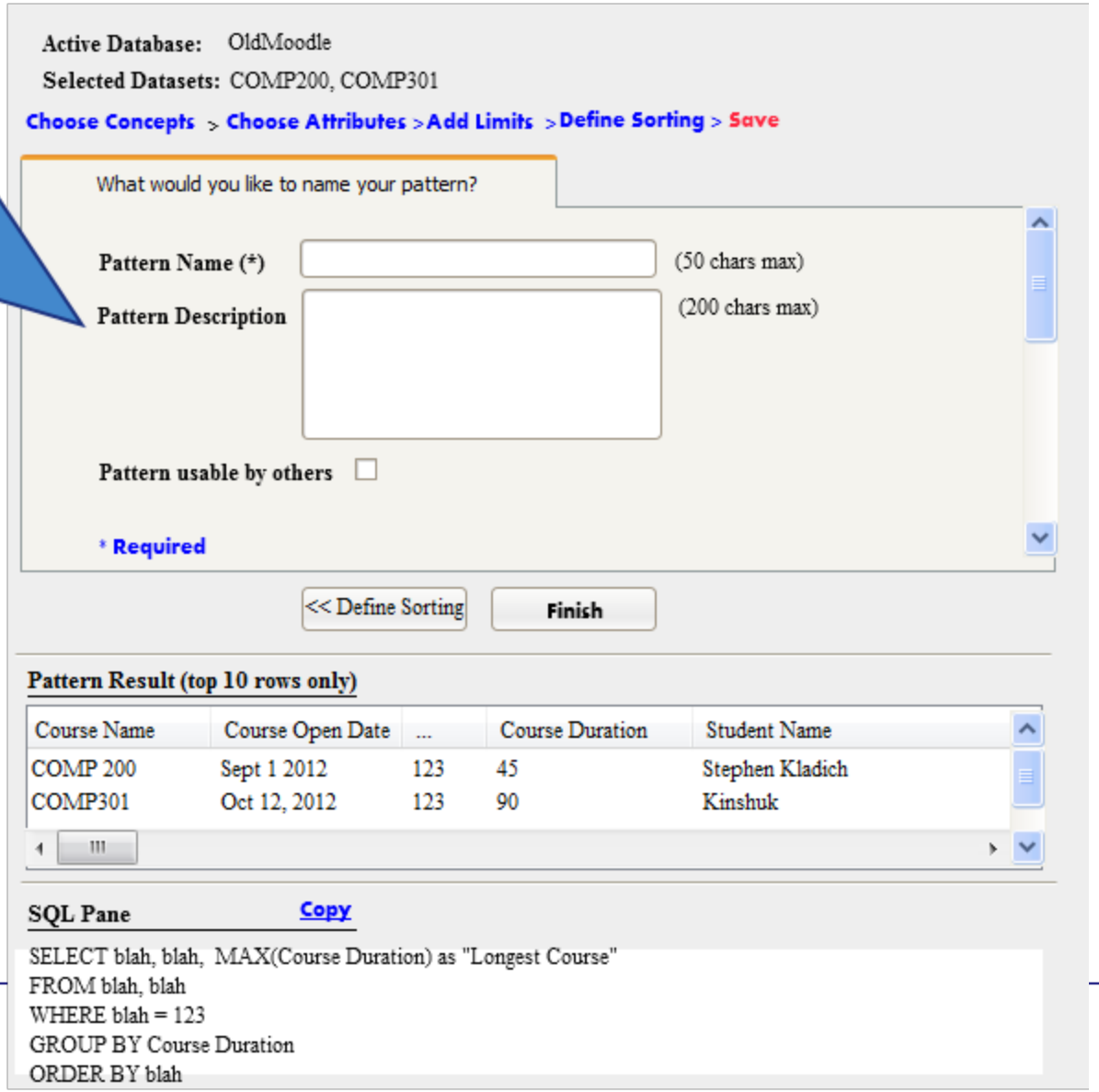
At this point the concepts are listed in order they were clicked in "Choose Attributes"

Sort Order arrows are clickable and will physically move the attribute up or down on this list As user clicks sort type for an attribute, the attribute moves to next spot on list AND only arrows for selected attributes Sort order will be order of the list as displayed (only sleected).



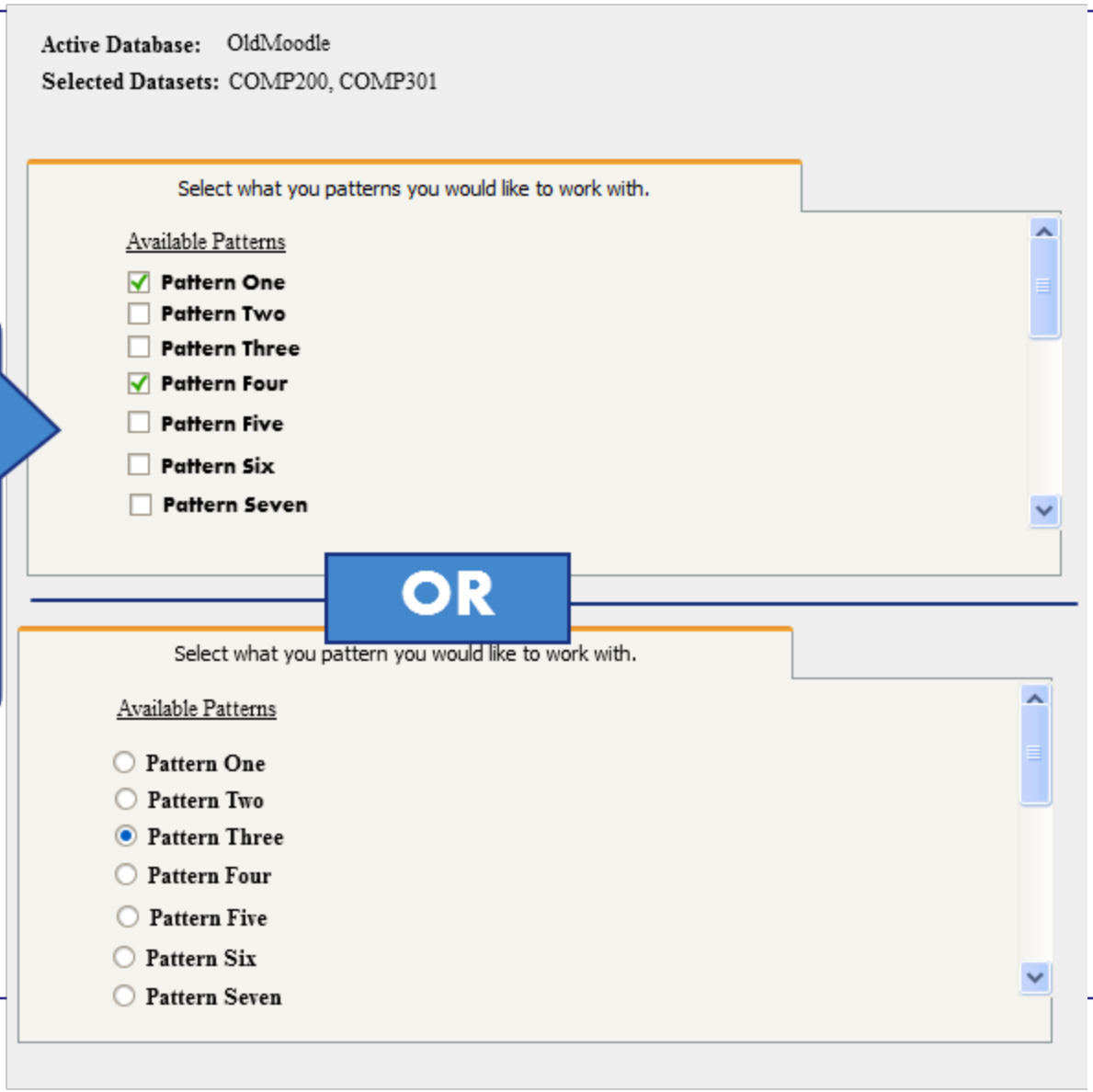
Save

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.



Select Pattern

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 computeed column is in the result.

Thus this part removes all other columns from the select list and

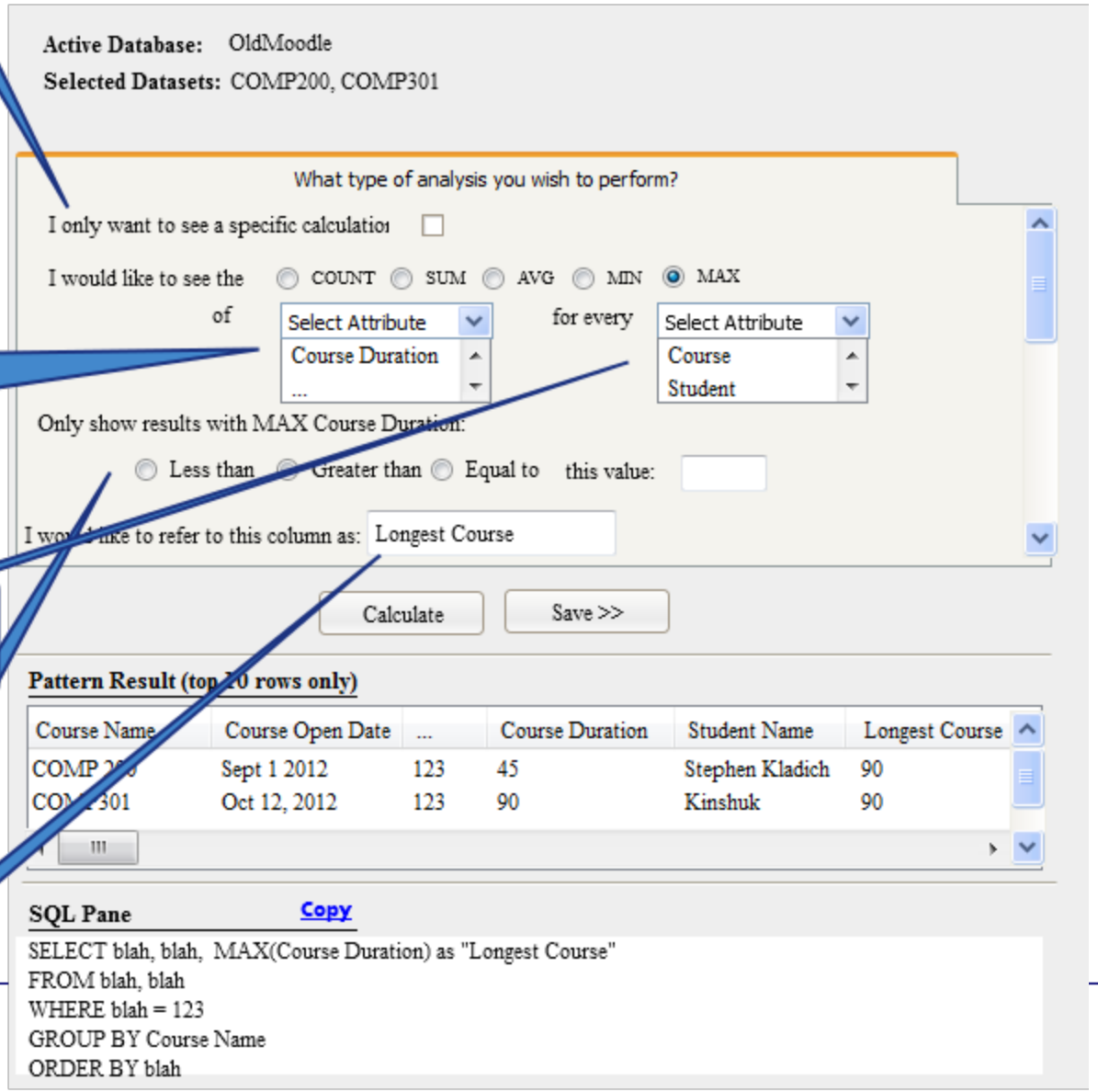
Only those attributes that are of a numerical data type in the source pattern will be listed here.
Calculations: COUNT/AVG /SUM/MIN/MAX

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 apha numerics are here.



Group activity

How can AAT be extended and used in an ubiquitous setting?

1. Build teams of 3-4 students
2. Select an ubiquitous learning scenario (e.g., learning in museum, zoo, etc.)
3. Think about the types of data that the tool can provide users (teachers, course designers, etc.) access to
4. Think about how users (teachers, course designers, etc.) can benefit from the data
5. Present and discuss ideas to other teams