



Athabasca University 

SCHOOL OF COMPUTING & INFORMATION SYSTEMS

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# **An Architecture for Dynamic Student Modelling of Learning Styles in Learning Systems and its Application for Adaptivity**

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# Why learning styles?

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- Why shall we consider learning styles in technology enhanced learning?
  - Complex and partially inconsistent field
  - Learners have different ways in which they prefer to learn
  - If those preferences are not supported, learners can have difficulties in learning

# Why modelling students' learning styles?

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- Benefits of knowing students' learning styles
  - Make students aware of their learning styles
  - Make teachers aware of their students' learning styles
  - Basis for providing adaptivity based on learning styles

# Types of Student Modelling

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## ■ Collaborative vs. Automatic

- Collaborative: asking students directly for feedback
- Automatic: inferring students' characteristics from their behaviour and actions

## ■ Benefits of Automatic Student Modelling

- Students have no additional effort
- Approach is direct and free from the problem of inaccurate self-conceptions
- Data are gathered over a period of time → more accurate
- Dynamic aspects can be considered

## ■ Challenge of Automatic Student Modelling

- Takes some time to get enough data for initializing the student model

# Types of Student Modelling

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## ■ Static vs. Dynamic

- Static: student model is built once
- Dynamic: student model is frequently updated based on new data

## ■ Advantages of Dynamic Student Modelling

- incrementally improve and fine-tune the information in the student model in real-time
- consider exceptional behaviour of students
- identify and response to changes in students' learning styles over time

# Aim of Research

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- Many adaptive systems use questionnaires
- Recent research deals with automatic & static student modelling of learning styles (e.g., Cha et al. 2006, Garcia et al. 2007, Graf et al. 2009)
- Focus of this paper is on automatic & dynamic student modelling of learning styles
- Proposes an generic architecture for automatic and dynamic student modelling of learning styles which can extend existing learning systems
- Demonstrate the architectures' application in a particular learning system

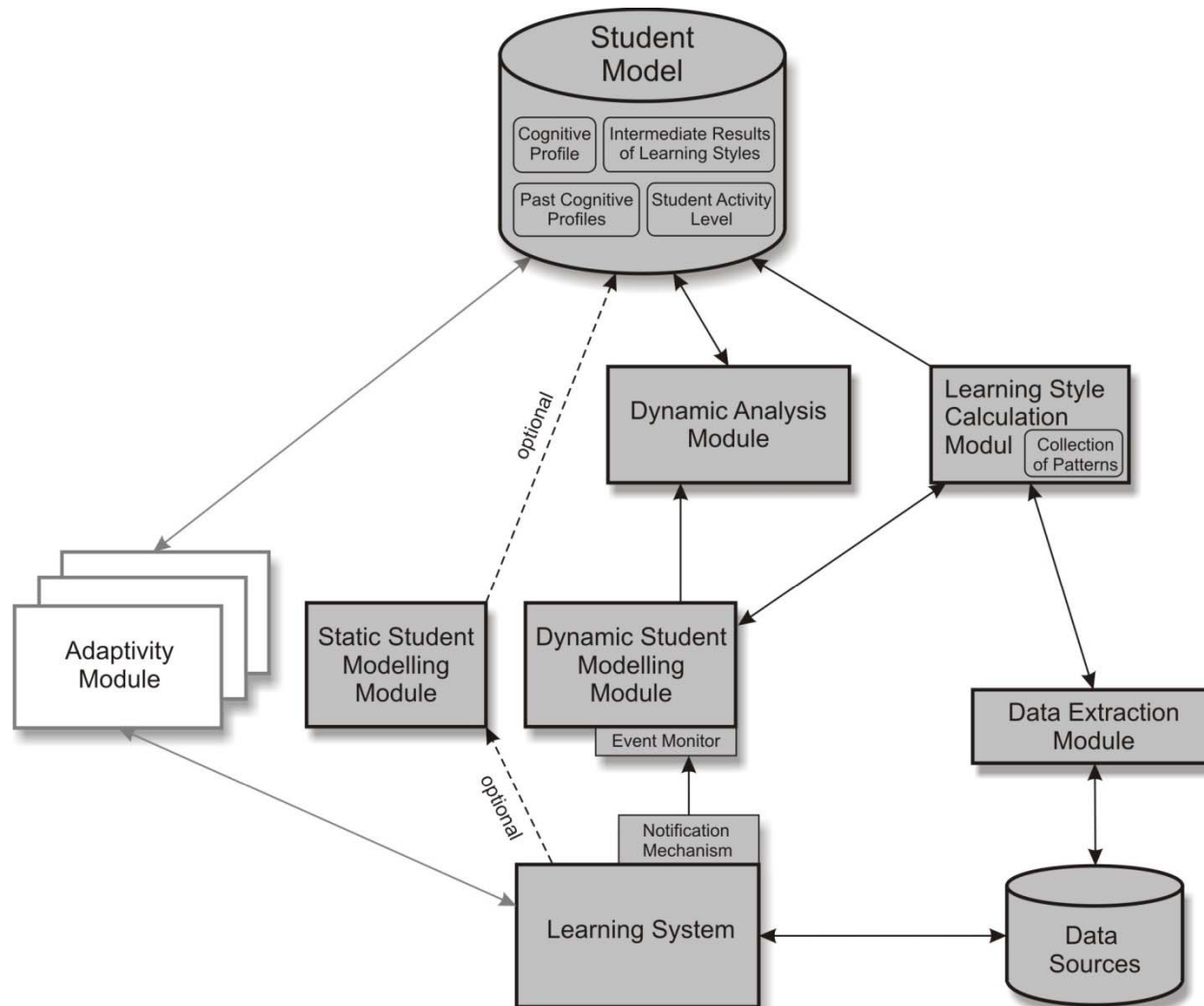
# Felder-Silverman Learning Style Model

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- 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“



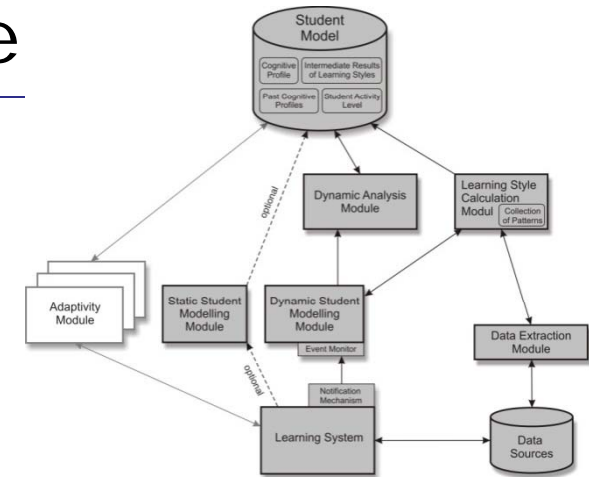
# Architecture





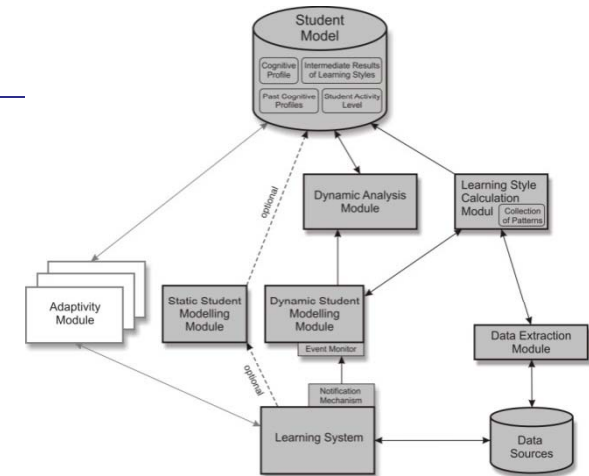
# Static Student Modelling Module

- Option for initialising the cognitive profile through a questionnaire (Index of Learning Styles by Felder & Soloman)
- Helps in quickly gather information about students' learning style
- Adaptivity can be provided right after students filled out the questionnaire
- Use dynamic student modelling to fine-tune and revise the information in the cognitive profile of the student model



# Notification Mechanism

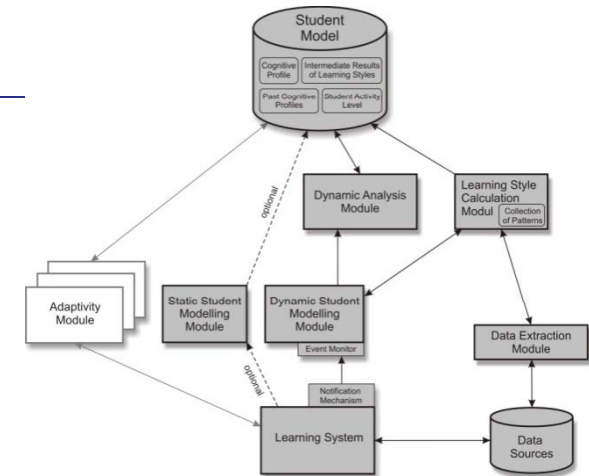
- System-dependent component
- Interface between learning system and *Dynamic Student Modelling Module*
- Responsible for notifying the *Dynamic Student Modelling Module* when a student performed an action in the learning system (e.g., visits of learning objects/activities)



# Dynamic Student Modelling Module

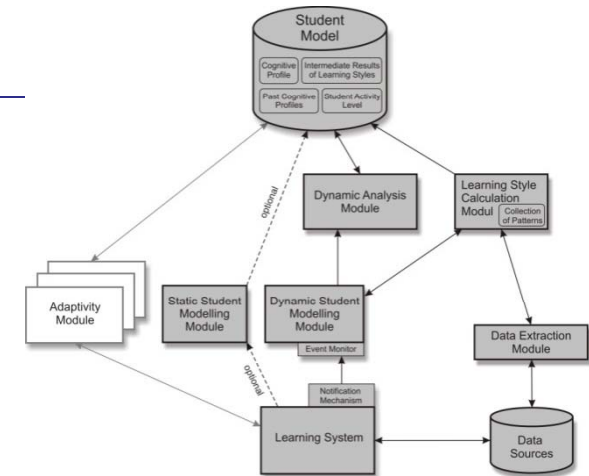
- Responsible for managing the dynamic student modelling process

1. Monitors students' activity level based on the messages received from the notification mechanism
2. Requests recalculation of students' learning styles based on their recent behaviour once a student performed a predefined number of actions since the last recalculation
3. Requests checking whether the cognitive profile should be updated



# Learning Style Calculation Module

- Aims at calculating students' learning styles from their behaviour in the system
- Calculation is based on a collection of behaviour patterns
- Each pattern provides indications for identifying learning styles based on a particular dimension of the FSLSM
- Not all patterns can be included in all systems

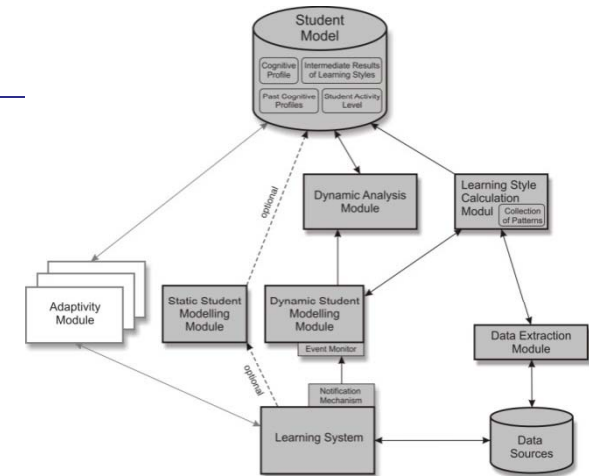


# Learning Style Calculation Module

## ■ Steps

- Request raw data from Data Extraction Module
- Transform raw data to ordered data based on thresholds from literature (→ high, medium, low, no information)
- Relate ordered data to how the patterns affects the respective learning style dimension (→ strong indication, average, disagreement, no information)
- Sum up values per dimension and divide by number of available patterns (→ measure for the respective learning style dimension)
- Normalise to values between 0-1

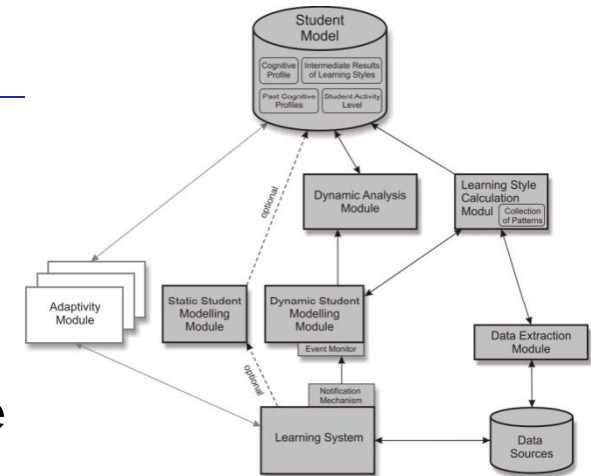
- Approach has been successfully evaluated in Graf et al. (2009)



# Learning Style Calculation Module

## ■ Once learning styles are calculated

- They are stored in the cognitive profile of the student model
- Learning Style Calculation Module reports the completion of the calculation to the Dynamic Student Modelling Module

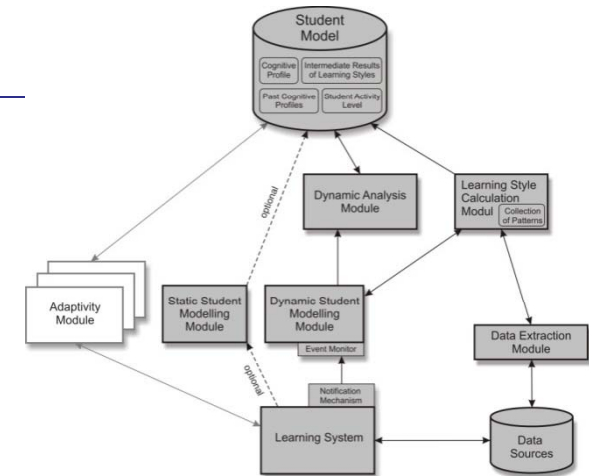


# Data Extraction Module

- Once the Data Extraction Module receives a request from the Learning Style Calculation Module, it

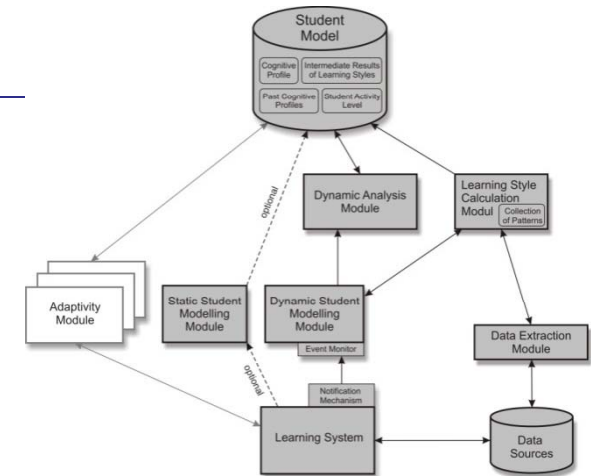
- connects to the learning system's database (or other data sources)
- extracts data from available patterns
- sends the extracted data back to the Learning Style Calculation Module

- Data Extraction Module is system-dependent since data extraction depends on where data are located



# Dynamic Analysis Module

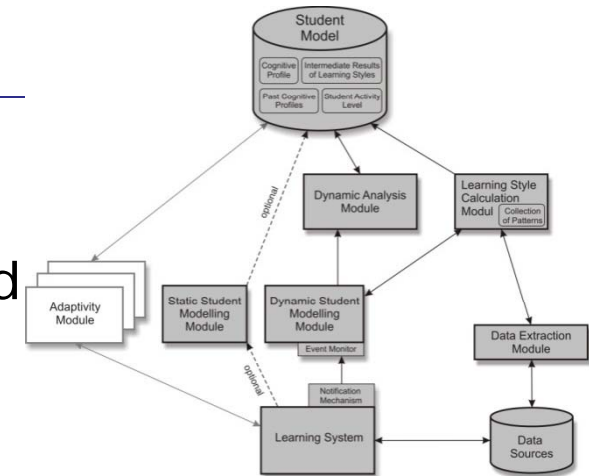
- Responsible for analysing how the learning styles change over time and whether these changes should lead to a change in the learning styles stored in the cognitive profile
- Two objectives for such a change:
  - The currently stored learning style should reflect the current learning style of students as good as possible → updating as soon as a revision can be done
  - Considering deviations of students' behaviour and having as less as possible revisions which are then taken back shortly afterwards





# Dynamic Analysis Module

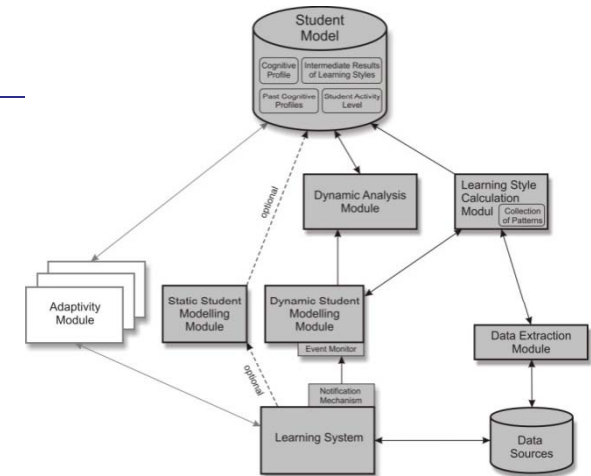
- The Dynamic Analysis Module integrates an approach that has been introduced and evaluated by Graf and Kinshuk (2009)
- Three conditions are used in order to decide whether a learning style should be updated
  - Difference between stored learning style and average learning style from current and past data
  - Difference between currently identified learning style ( $d_t$ ) and previously identified learning style ( $d_{t-1}$ )
  - Compare difference between previously identified learning style ( $d_{t-1}$ ) and stored learning style as well as the difference between currently identified learning styles ( $d_t$ ) and stored learning style
- If all three conditions point to a change in a student's learning styles (rather than an exceptional behaviour), the learning style in the cognitive profile is updated



# Student Model

- Aims at storing several types of information about students

- Cognitive profile, including 4 values of students' learning styles  
→ can be accessed by adaptivity modules to provide learners with adaptive recommendations/courses
- Students' activity level
- Past data from the cognitive profile
- Intermediate results from the Static Student Modelling Module including data from the questionnaire
- Intermediate results from the Learning Style Calculation Module representing the identified learning styles over time based on students' behaviour



# Application of the Architecture

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- Architecture has been implemented for a learning system
  - Notification Mechanism has been integrated in the system
  - Data Extraction Module has been adjusted to the learning system's data sources and available patterns
  - Adaptivity Module has been developed that uses the information about students' learning styles

# Course Structure

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## ■ Two types of courses

### ● Assessment only

- Exercises
- Quizzes
- Study Guide

### ● Assessment & Content

- Exercises
- Quizzes
- Study Guide
- Outline
- Learning material
- Applied self-assessment questions
- Theoretical self-assessment questions
- Activity-related questions
- Case studies

# Available Patterns

Pattern name	Description of patterns	act/ref
exercise_stay	avg. time spent on solving an exercise question	ref
exercise_visits	avg. number of attempts to solve an exercise question	act
exercise_performance_increase	avg. rate of grade increase on exercise questions	ref
exercise_performance	avg. final grade on exercise questions	
exercise_stay_results	avg. amount of time spent for studying the feedback of exercise questions	ref
exercise_sequence_skip	number of times of skipping an exercise question*	
exercise_sequence_back	number of times of going back to a previous exercise question*	
quiz_sequence_revise	number of times of re-entering a quiz*	
quiz_stay	percentage of time took on avg. for submitting a quiz	
quiz_stay_results	avg. amount of time for studying the feedback of a quiz	ref
studyguide_visits	number of visits of the study guide*	
outline_visit	number of visits of outlines*	
outline_stay	avg. amount of time spent on outlines	ref
content_visit	number of visits on content pages*	ref
content_stay	avg. amount of time spent on content pages	ref
content_back	number of times of re-visiting a content page*	
content_skip	number of times for skipping content pages*	
asa_solution_visit	number of visits of solutions of applied self-assessment questions*	
asa_solution_stay	avg. amount of time spent on solutions of applied self-assessment questions	ref

# Providing Adaptive Feedback

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- The proposed architecture is intended to be combined with an adaptivity module that uses the information about students' learning styles to provide students with adaptivity
  - Adaptivity modules have strong interdependencies with the system and are therefore system dependent
  - The developed adaptivity module provides adaptive feedback within the study guide
  - The feedback includes
    - Their learning styles
    - Explanation of their learning styles (pointing out typical characteristics, strengths and weaknesses of student with these particular learning styles in a general learning context)
    - Personalized learning advise including suggestions on how to learn more effectively
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# Conclusions & Future Work

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- We proposed an architecture for dynamically identifying students' learning styles
- The architecture can be used for different learning systems (with only few adjustments)
- The application of the proposed architecture has been demonstrated and an adaptivity module has been developed
- Through dynamic student modelling, learning styles can be refined, improved and updated frequently, leading to more accurate identification of students' learning styles and therefore to more accurate adaptivity
- Future work
  - Developing additional adaptivity modules
  - Extending the collection of patterns
  - Extending the application of the architecture to other systems
  - Qualitative evaluation to investigate students' satisfaction with the provided adaptivity