Athabasca University
FACULTY OF SCIENCE & TECHNOLOGY
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Adaptive and Intelligent Technologies for Learners and Teachers

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Adaptivity and Personalization in Learning Systems

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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

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- Considering students' characteristics and context
  - Learning styles
  - Cognitive traits
  - Motivational aspects
  - Communication patterns and group progress (in collaborative learning)
  - 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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  - **Learning styles**
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  - Easy access to educational log data
  - Identification of students at risk of failing a course
- Different settings
  - **Learning management systems**
  - Mobile / Ubiquitous learning

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Why aiming at enabling learning management systems to adapt to students' characteristics?

Why Learning Management Systems?

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- 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

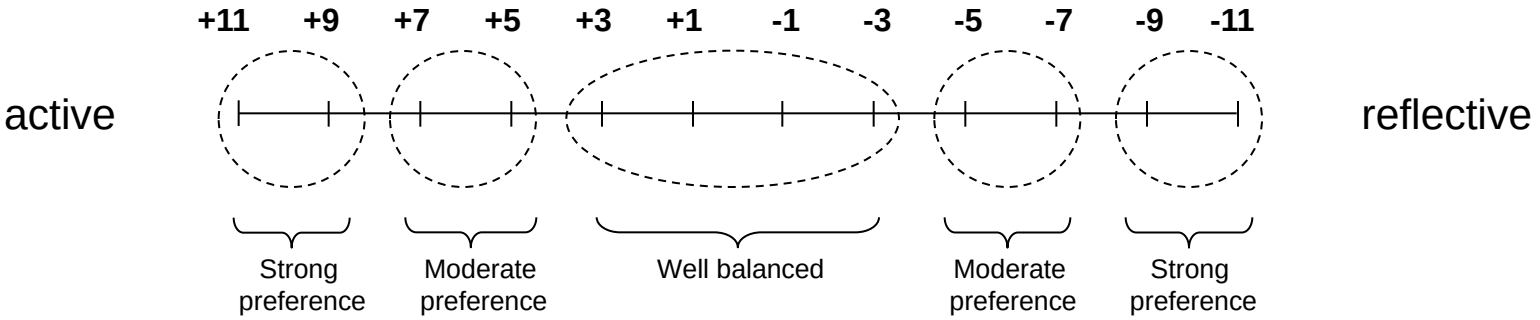
Felder-Silverman Learning Style Model

- 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

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- 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 <-> Scale)
  - Represents also balanced preferences
  - Describes tendencies
  - Domain-independent
  - Are “flexible-stable” over time

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How to automatically identify students' learning styles?

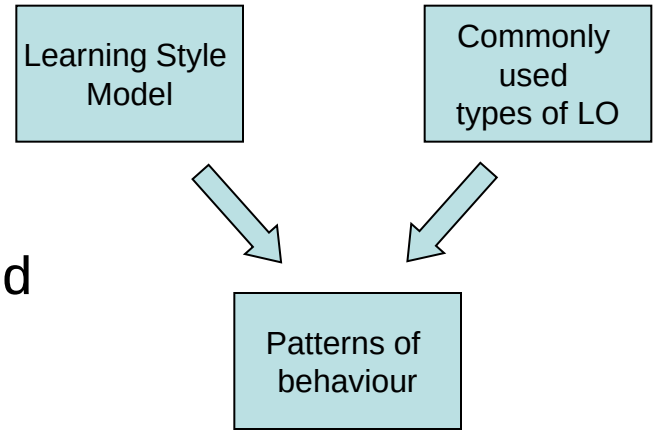
Research Question

How to automatically identify students' learning styles in typical LMSs?

- Develop a concept which enables LMS to automatically identify students' learning styles from their behaviour in a course
- Keep the concept generic so that it can be used for different LMS
- Implement and evaluate the concept in one particular LMS

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 (-)		

14

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:

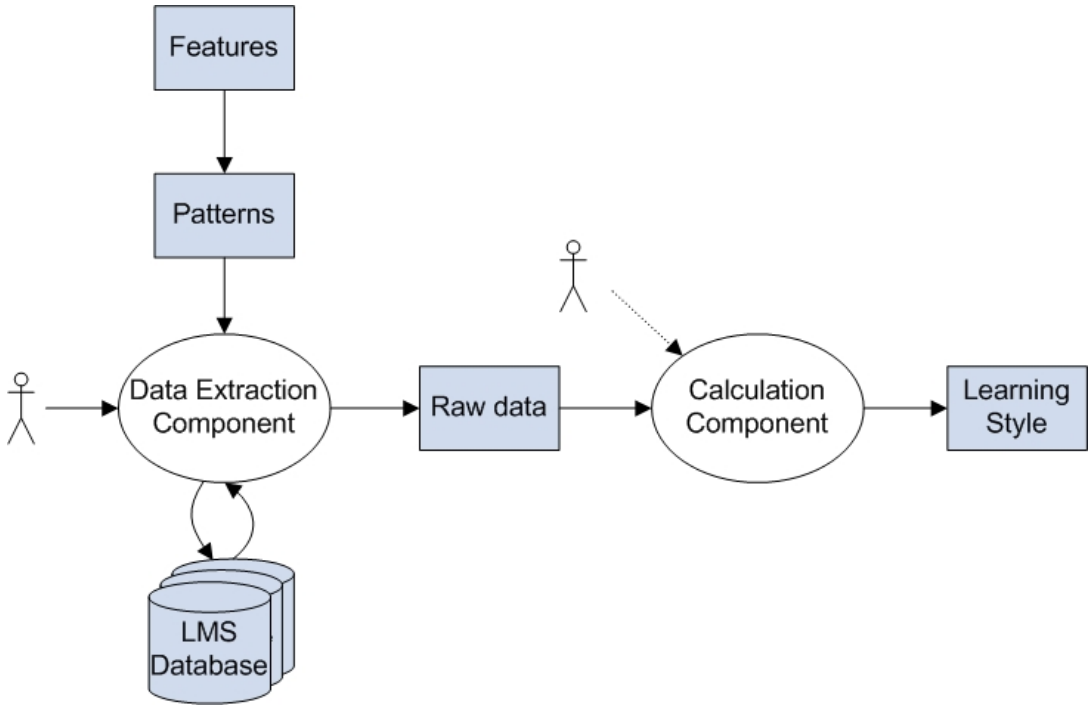
Approach	Act/Ref	Sen/Int	Vis/Ver	Seq/Glo
Literature-based approach	**0.799**	**0.790**	**0.788**	0.702
Bayesian Networks [1]	0.580	0.770	-	0.630
NBTree [2]	0.7	0.733	0.533	**0.733**

[1] García P, Amandi A, Schiaffino S, Campo M (2007) Evaluating bayesian networks' precision for detecting students' learning styles. Computers & Education 49 (3):794-808

[2] Özpolat E, Akar GB (2009) Automatic detection of learning styles for an e-learning system. Computers & Education 53 (2):355-367

Tool for Identifying Learning Styles

- Developed a stand-alone tool for identifying learning styles in learning systems



Improvements through Computational Intelligence Techniques

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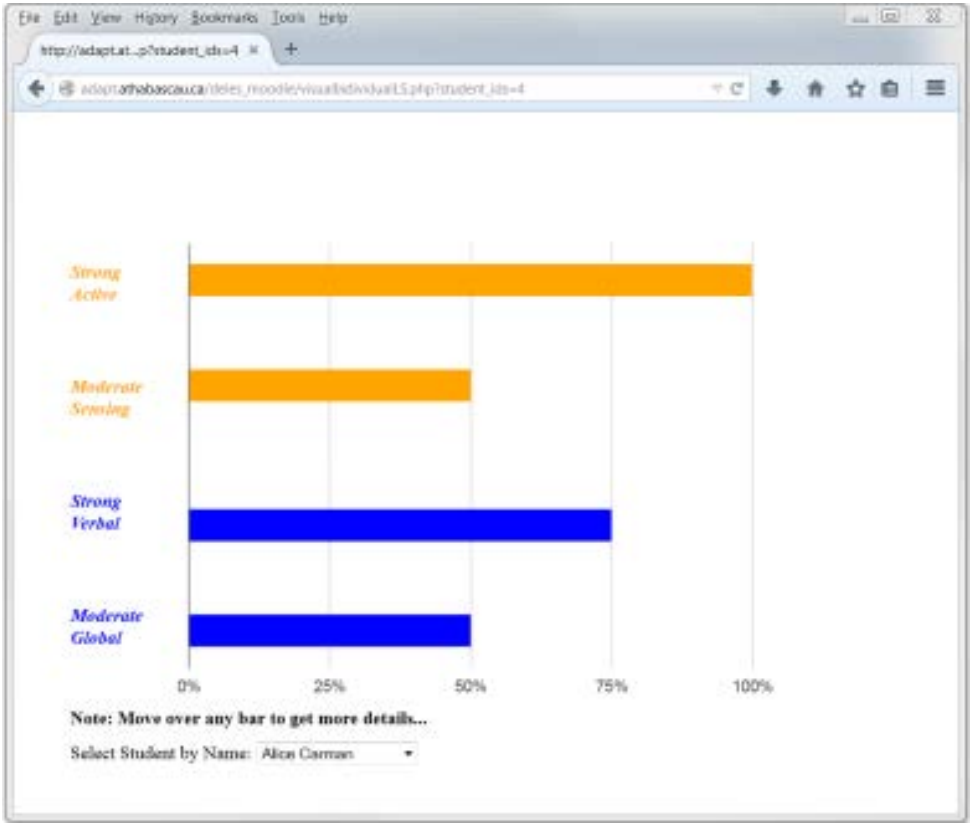
- Use neural networks to classify behaviours
- Use optimization algorithms (genetic algorithms, ant colony optimization, particle swarm optimization) to find out the weight of patterns
- Results:

Approach	Act/Ref	Sen/Int	Vis/Ver	Seq/Glo
Literature-based approach	0.799	0.790	0.788	0.702
Artificial Neural Networks	0.802	0.790	**0.840**	**0.797**
Genetic Algorithm	0.773	0.784	0.801	0.781
Ant Colony System	**0.808**	**0.804**	0.797	0.730
Particle Swarm Optimization	0.805	0.792	0.796	0.753

Visualization of Learning Style

- Teachers can see students' learning styles



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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]

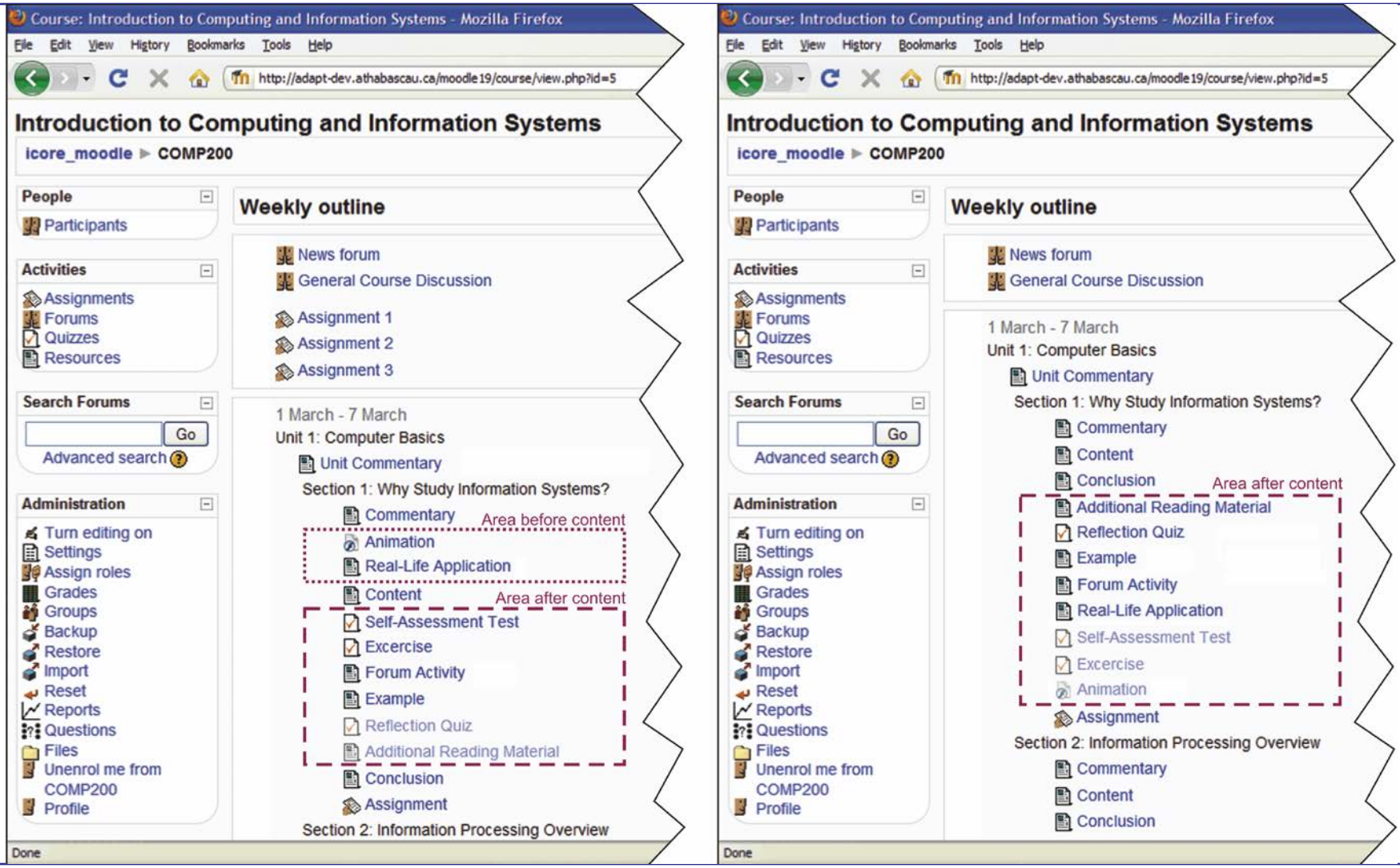
Aims and Benefits

- 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)

How to provide adaptivity?

- Based on 12 types of learning objects which can but don’t have to be included in the course
- Providing adaptive courses through
  - adaptive annotations
  - adaptive sequencing

Adaptivity in LMSs



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

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How to provide adaptive support for collaborative learning?

Motivation

- Collaborative learning is an essential aspect in the learning process, where students learn important skills such as communication and interpersonal skills
- However, especially in distance education, working together in groups is often difficult

Aim

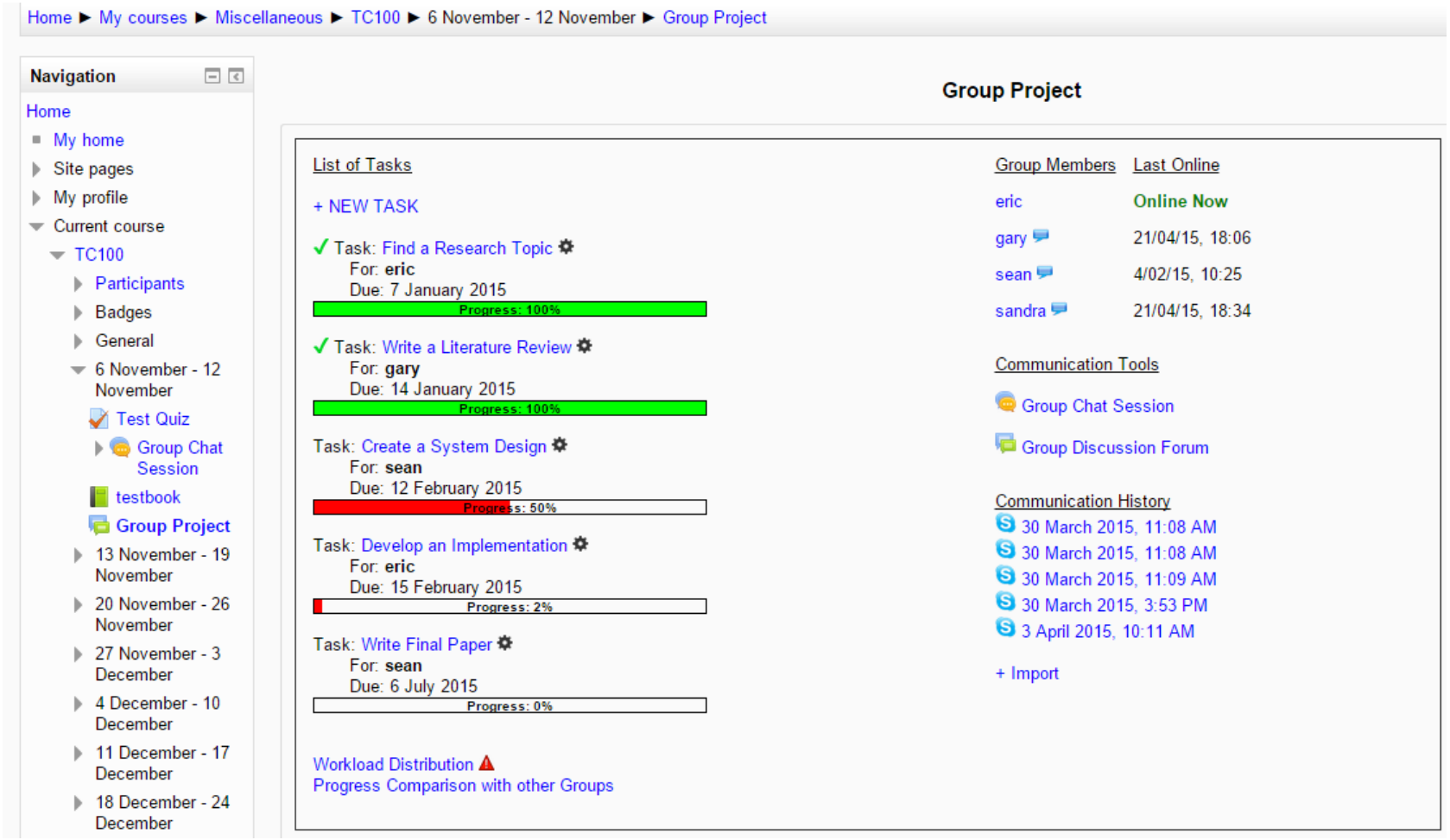
- Focus on two main areas of collaborative learning:
  - Communication
  - Project management
- Aim at providing adaptive features to support individual learners and the whole group
- Research steps:
  - Develop a concept which enables LMS to automatically identify students' learning styles from their behaviour in a course
  - Keep the concept generic so that it can be used for different LMS
  - Implement and evaluate the concept in one particular LMS

[Jeff Kurcz, Ting-Wen Chang]

Communication

- Providing a rich communication environment where students can access a variety of communication tools from one place
- Available communication tools:
  - Forum
  - Chat
  - Messages
  - Online status
- Support import of communications from external tools (e.g., emails and Skype)

Main Interface



Adaptive Recommendations based on Communication Patterns

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- Adaptive Recommendations are provided based on communication data from students (either within the learning environment or imported)
- Three behaviors are identified:
  - Low Attendance
    - System checks how often a student attends group meetings
    - If the student missed more than 20% of the meetings, the student receives an alert when he/she is logging in

Adaptive Recommendations based on Communication Patterns

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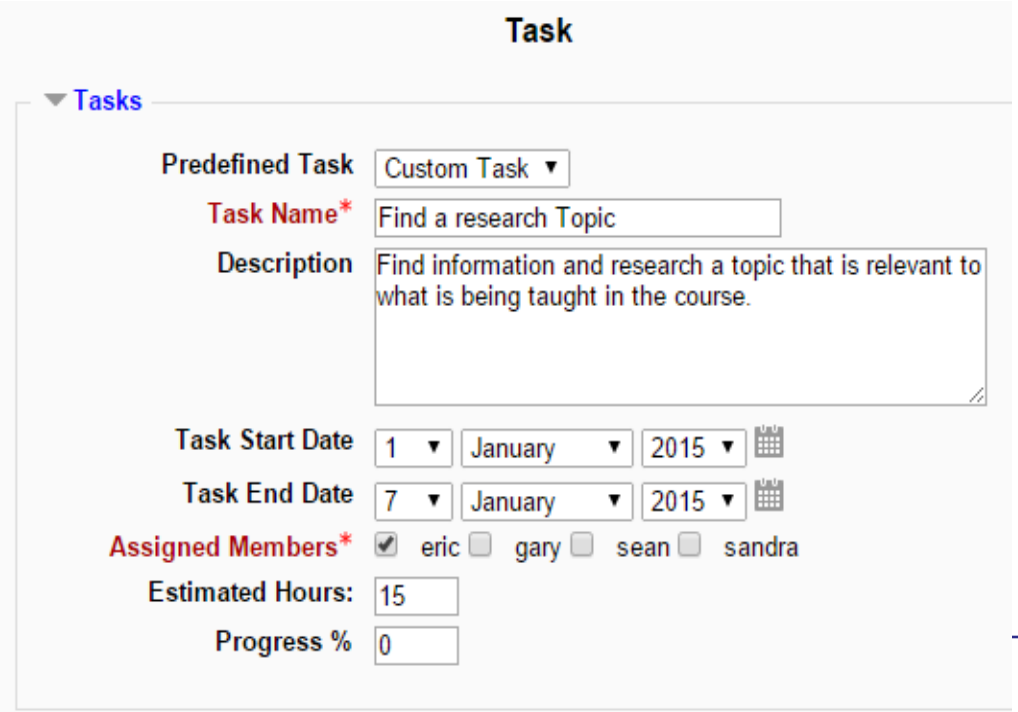
- Significantly Less Contributions
  - System checks how much students are contributing to discussions, using the number of postings and their length as indicators
  - If a student contributes significantly less than others, the system provides the student with advise on how to contribute more, depending on the used communication tool
- Significantly More Contributions
  - If a student contributes significantly more than others, the system identifies this student as leader and
    - provides the student with advise on how to incorporate others in the discussion, based on the used communication tool
    - advises on which students should be encouraged first

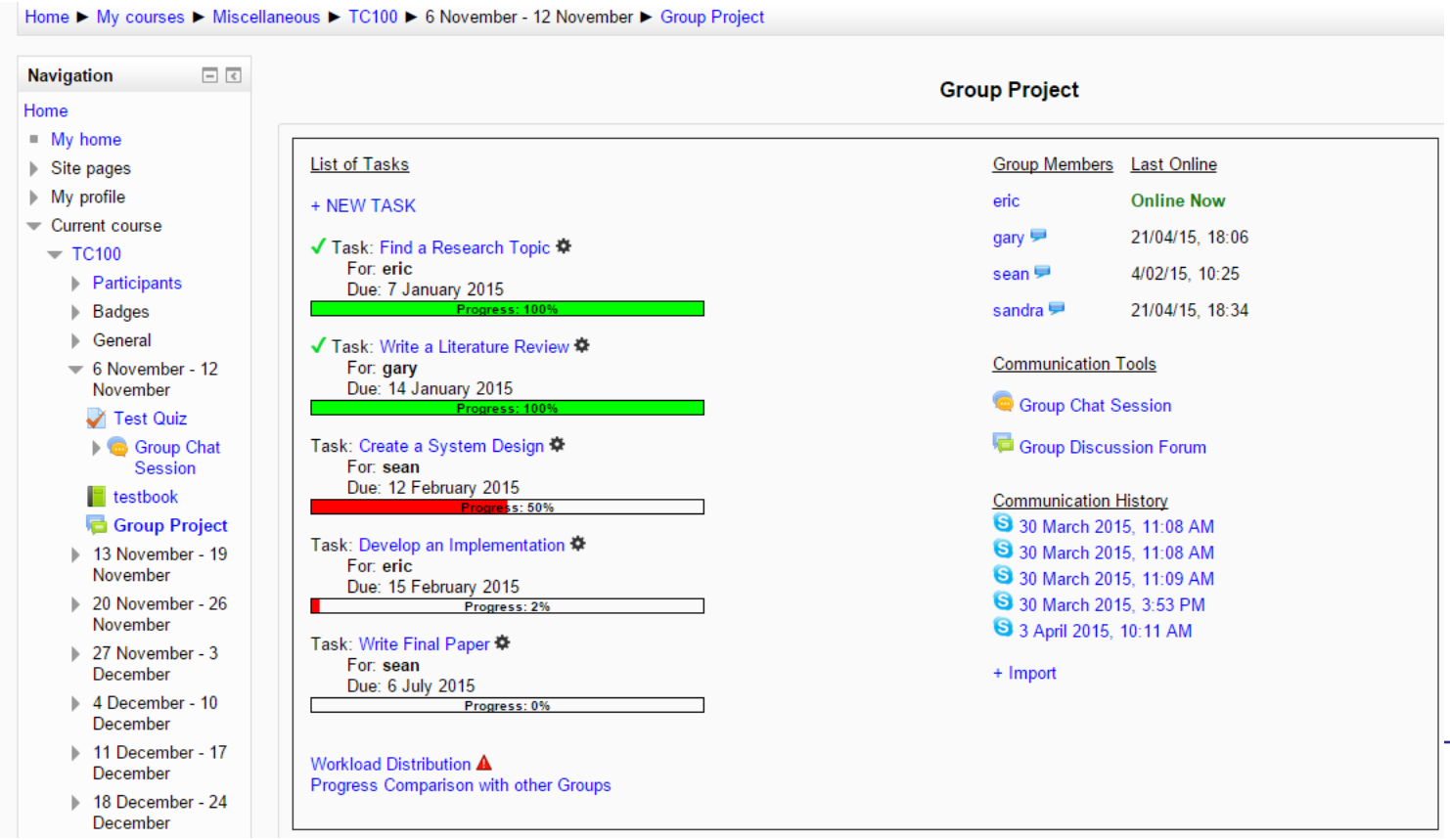
Project Management

- Provide a project management environment where students can:
  - Create tasks for their projects (either new ones or predefined ones)



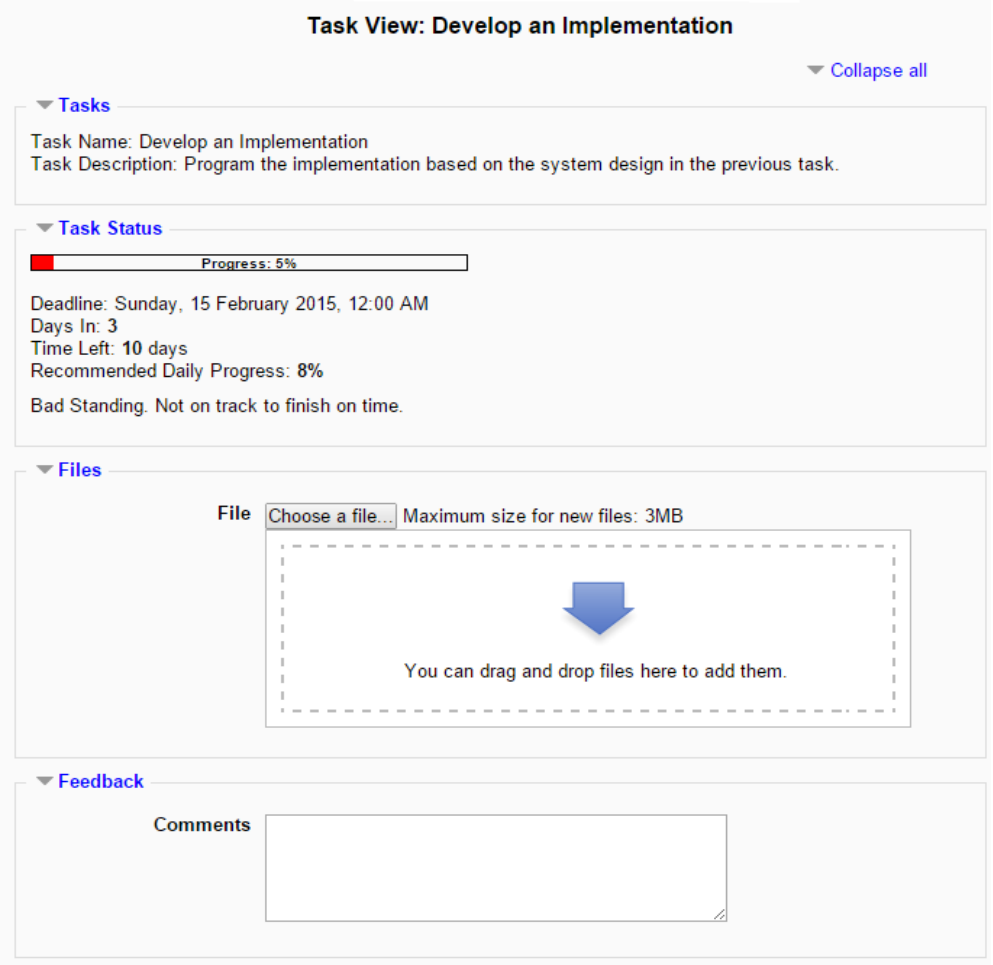
Project Management

- See the most relevant information on the main interface (including the task name, who is assigned to the task, due date and progress)



Project Management

- Edit a task and update progress
- See statistics on the task
- Upload a file and comment on uploaded files



Ensuring Equal Workload Distribution

- One of the problems in group works is that some students do a lot of work, while others don't do so much
- ACS provides groups with information on the workload distributions and alerts them if there is one or more students who have significantly less or more work

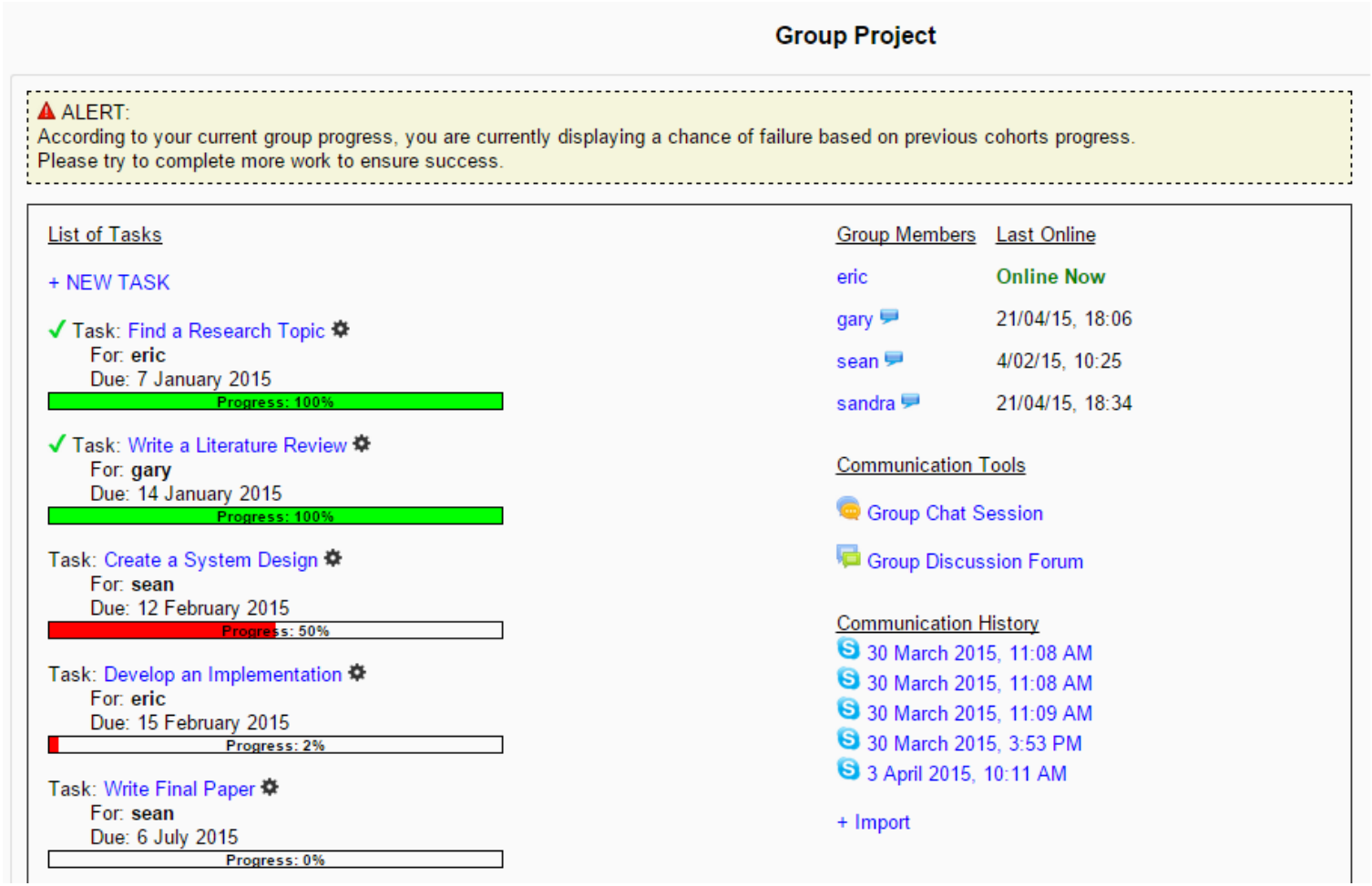
Individual Recommended Hours: 35 Hours

Member	Assigned Hours	% of Workload	Variance
Eric Bondy	80	57.14	129% ⚠
Gary Long	40	28.57	
Sean Smith	20	14.29	-43% ⚠
Sandra Young	0	0	-100% ⚠
Total	140	100	

At-Risk Identification

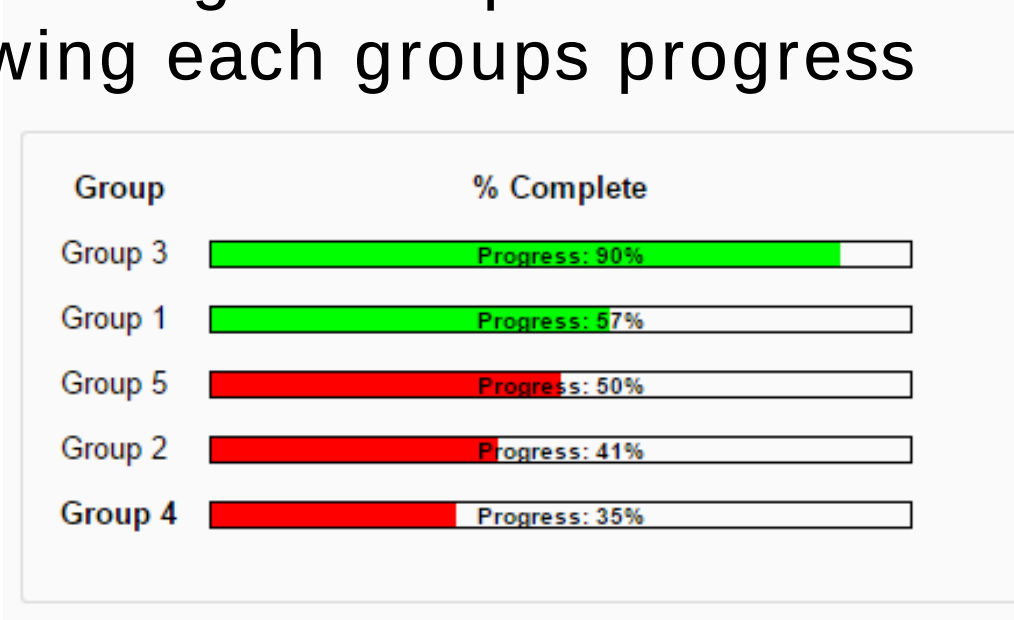
- Another problem in group works are delays, which can seriously impact the outcome/success of the project
- ACS analyses the progress and outcome of past groups who either failed or completed the project successfully
- Based on information from past groups, ACS identifies whether a group is at risk of failing
- If so, ACS alerts each team member and provides them with information on their risk level

At-Risk Identification



Increasing Motivation

- Motivation is an important aspect in learning and, in particular in collaborative learning
- ACS implements a motivational technique that encourages competition between groups by showing each groups progress



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Questions

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