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Automatic student modelling for detecting learning style preferences in learning management systems

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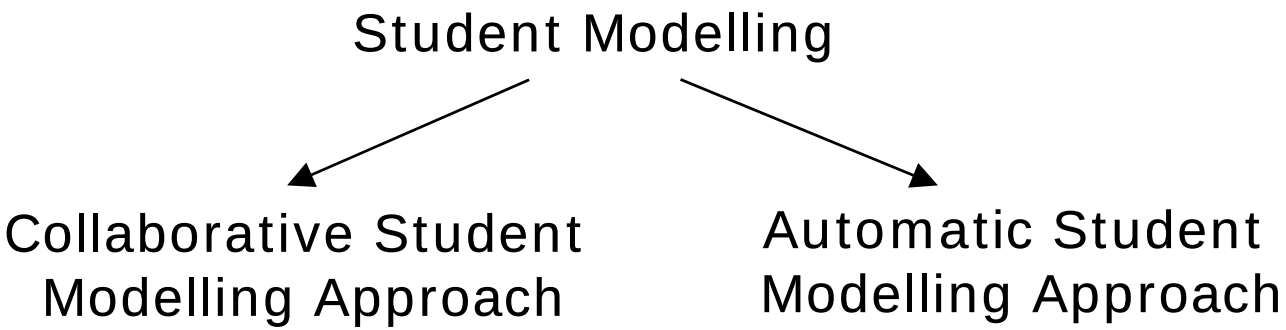
Why do we aim at detecting learning styles

- Information about learning styles can be used
  - Awareness of students' learning styles
  - Requirement for providing adaptivity
- Learning Management Systems (LMS) are commonly used in e-education
- Approaches for identifying learning styles:



Student Modelling for Identifying Learning Styles

- Collaborative Student Modelling
  - Ask students explicitly for informations
  - Learning styles: Questionnaires
  - Problems with questionnaires
    - Reliability & validity of the instrument
    - Motivate students to fill it out
    - Non-intentional influences
    - Static instrument

Student Modelling for Identifying Learning Styles

- Automatic student modelling
  - What are students really doing in an online course?
  - Infer their learning styles from their behaviour
  - Advantages:
    - Students have no additional effort
    - Uses information from a time span → higher tolerance
  - Problem/Challenge:
    - Get enough reliable information to build a robust student model

→ Aim is to automatically identify learning style preferences based on the behaviour and actions of learners in LMS

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“
    serial – holistic

Index of Learning Styles (ILS)

- Developed by Felder and Soloman to identify learning styles
- 44 questions
- 11 questions for each dimension
- Each question allows two possible answers indicating a preference for either the one or the other pole of the learning style dimension; e.g. active (+1) or reflective (-1)
- Result: a value between +11 and -11 for each dimension

Grouping of Learning Style Preferences

- Previous study:

  Groups of preferences within learning styles dimensions were analysed and their relevance for each dimension was investigated

Style	Semantic group	ILS questions (answer a)	Style	Semantic group	ILS questions (answer b)
Active	trying something out social oriented	1, 17, 25, 29 5, 9, 13, 21, 33, 37, 41	Reflective	think about material impersonal oriented	1, 5, 17, 25, 29 9, 13, 21, 33, 41, 37
Sensing	existing ways concrete material careful with details	2, 30, 34 6, 10, 14, 18, 26, 38 22, 42	Intuitive	new ways abstract material not carefule with details	2, 14, 22, 26, 30, 34 6, 10, 18, 38 42
Visual	pictures	3, 7, 11, 15, 19, 23, 27, 31, 35, 39, 43	Verbal	spoken words written words difficulty with visual style	3, 7, 15, 19, 27, 35 3, 7, 11, 23, 31, 39 43
Sequential	detail oriented sequential progress from parts to the whole	4, 28, 40 20, 24, 32, 36, 44 8, 12, 16	Global	overall picture non-sequential progress relations/connections	4, 8, 12, 16, 28, 40 24, 32 20, 36, 44

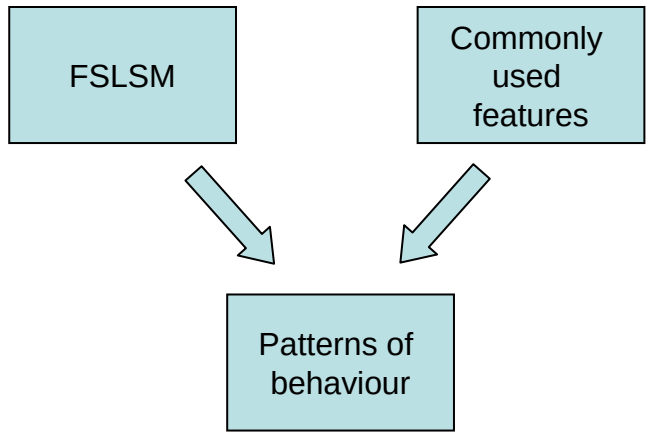
Grouping of Learning Style Preferences

- Semantic groups within learning style dimensions provides more accurate information about learning styles
- Learners who have a balanced learning style on the active/reflective dimension can, for example, prefer ...
  - Trying something out & impersonal oriented
  - Thinking about the material & social oriented

  → Same result in ILS but different behaviour in the course
- Considering semantic groups leads to more accurate information and therefore to a more accurate model for identifying learning styles

Investigated Patterns

- Felder and Silverman describe how learners with specific preferences act in learning situations
- Mapped the behaviour to online learning
- Only commonly used features are considered:
  - Content objects
  - Outlines
  - Examples
  - Self-assessment tests
  - Exercises
  - Discussion Forum



Investigated Patterns

- Content objects, outlines and examples
  - Number and time of visits
- Selfassessment-tests
  - Number of answered questions
  - Time until submitting the test
  - Number of revisions
  - Performance on specific types of questions (facts/concepts, details/overview, graphics/text, interpreting solutions/developing solutions)
  - Answering the same question twice wrong
  - Time on reviewing the results

Investigated Patterns

- Exercises
  - Number of performed exercises
  - Time until submitting the exercises
  - Performance on questions about interpreting solutions/developing new solutions
  - Number of performed revisions
  - Time for reviewing the results
- Discussion Forum
  - Number of visits
  - Time spent in the discussion forum
  - Number of postings
- Navigation
  - Number of skipped learning objects (via the navigation menu)
  - Number of visits of the course overview page
  - Time spent on the course overview page

Relevant Patterns

- Sensing/Intuitive Dimension

Sensing Learning Style			Intuitive Learning Style		
concrete material	existing ways	careful with details	abstract material	new ways	not carefule with details
example_visit (+)	example_visit (+)	selfass_stay (+)	content_visit (+)	example_visit (-)	ques_detail (-)
example_stay (+)	example_stay (+)	ques_detail (+)	content_stay (+)	example_stay (-)	selfass_stay (-)
content_visit (-)	selfass_visit (+)	quiz_revisions (+)	example_visit (-)	selfass_visit (-)	quiz_revisons (-)
content_stay (-)	exercise_visit (+)	quiz_stay_results (+)	example_stay (-)	ques_develop (+)	quiz_stay_results(-)
ques_facts (+)	ques_develop (-)		ques_concepts (+)		
			ques_develop (+)		

Relevant Patterns

- Active/Reflective Dimension

Active Learning Style		Reflective Learning Style	
trying something out	social oriented	think about material	impersonal oriented
content_visit (-)	forum_visit (-)	content_visit (+)	forum_visit (+)
content_stay (-)	forum_post (+)	content_stay (+)	forum_post (-)
outline_stay (-)		outline_stay (+)	
example_stay (-)		selfass_visit (-)	
selfass_visit (+)		selfass_stay (+)	
selfass_twice_wrong (+)		selfass_twice_wrong (-)	
exercise_visit (+)		exercise_visit (-)	
exercise_stay (+)		exercise_stay (-)	
quiz_stay_results (-)		quiz_stay_results (+)	

Relevant Patterns

- Visual/Verbal Dimension

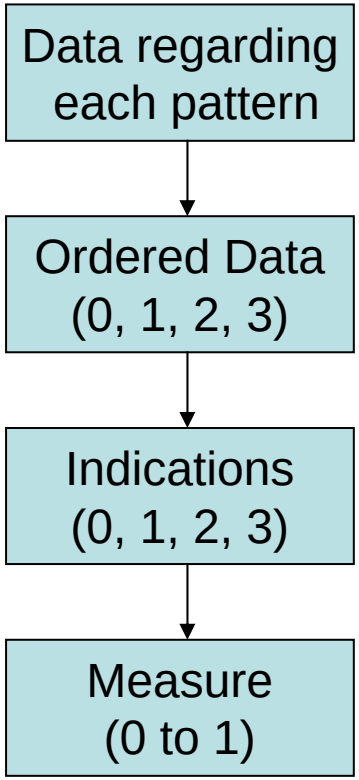
Visual Learning Style		Verbal Learning Style	
pictures	spoken words	written words	difficulty with visual style
content_visit (-)	-	content_visit (+)	ques_graphics (-)
ques_graphics (+)		ques_text (+)	
forum_post (-)		forum_visit (+)	
		forum_stay (+)	
		forum_post (+)	

Relevant Patterns

- Sequential/Global Dimension

Sequential Learning Style			Global Learning Style		
detail oriented	sequential progress	from parts to the whole	overall picture	non-sequential progress	relations/connections
outline_visit (-)	navigation_skip (-)	outline_visit (-)	outline_visit (+)	navigation_skip (+)	ques_overview (+)
outline_stay (-)	navigation_ overview_visit (-)	outline_stay (-)	outline_stay (+)	navigation_ overview_visit (+)	ques_intpret (+)
ques_detail (+)		navigation_ overview_visit (-)	ques_overview (+)		ques_develop (+)
navigation_ overview_visit (-)		navigation_ overview_stay (-)	navigation_ overview_visit (+)		navigation_ overview_visit (+)
navigation_ overview_stay (-)			navigation_ overview_stay (+)		navigation_ overview_stay (+)

Inferring Preferences of Semantic Groups from the Behaviour of Learners



Based on thresholds which are derived from literature and can be adapted if necessary

Based on relevant occurrence of behaviour

by summing up all indications, dividing it by the number of patterns where information was available, and normalising it

→ Preference of each student for each semantic group

Evaluation

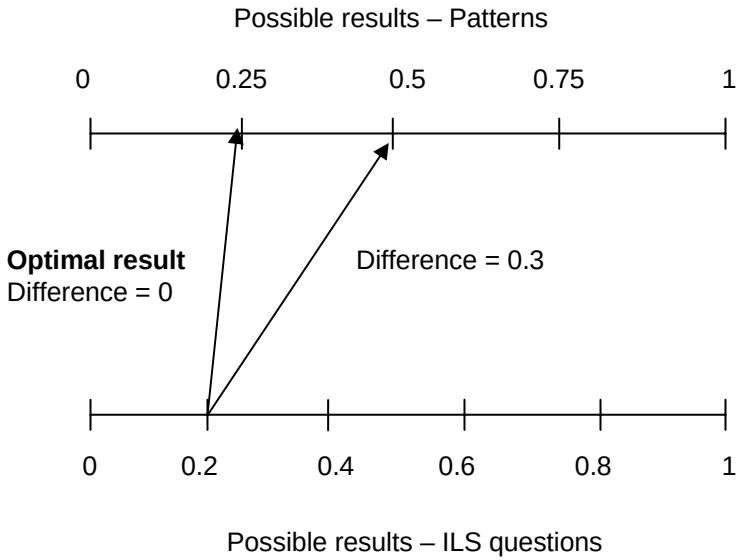
- University course about object-oriented modelling with 75 students
- Students filled out the ILS questionnaire and learned in the online course
- Method of evaluation
  - Automatic Approach:

    Measure based on indications (→ values between 0 and 1)
  - ILS:

    Calculated average preference for each semantic group based on the answers of ILS (→ values between 0 and 1)

Method of Evaluation

- Overall measure for comparing results from ILS and automatic approach considers the different number of patterns and questions



- For each semantic group, the absolute difference is calculated for all students, summed up, and divided by the number of students

Results

Dimensions	Semantic groups	Measure
Act/Ref	trying something out	**0.233**
	social oriented	**0.201**
	think about material	**0.242**
	impersonal oriented	**0.218**
Vis/Ver	pictures	**0.228**
	spoken words	-
	written words	**0.227**
	difficulty with visual style	0.263
Sen/Int	existing ways	0.318
	concrete material	**0.230**
	careful with details	**0.227**
	new ways	0.282
	abstract material	0.274
	not careful with details	0.305
Seq/Glo	detail oriented	0.399
	sequential progress	0.275
	from parts to the whole	0.309
	overall picture	0.293
	non-sequential progress	0.303
	relations/connections	0.344

Conclusions

- Proposed automatic student modelling approach
  - For identifying learning style preferences
  - Based on the behaviour and actions of students
  - Using a literature-based approach in combination with a simple rule-based method (similar to ILS) to calculate learning style preferences
  - Especially for LMS
- Evaluation shows that the approach is suitable for identifying
  - all preferences on the active/reflective dimension
  - some preferences on the visual/verbal and sensing/intuitive dimension
- Future work
  - Extending the proposed course structure in order to find patterns which help to identify the semantic groups with moderate or poor results
  - Extending the approach to a dynamic automatic student modelling approach

Questions

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