Predicting Student Learning Outcomes in Common Core Courses

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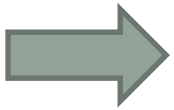
Outline

- Background
- Goals and Research Questions
- Learning Analytic Tool Design
  - Participatory design
  - A framework linking LMS activities and learning outcomes
  - Moodle tool prototype
- Prediction Models based-on Moodle Data
  - Build prediction models with feature selection
  - Apply models across years
- Discussions

Background

- Common Core Courses
  - University strategic theme
  - Challenging
    - Large class
    - Diverse student background
    - Broad coverage of content
    - Wide range of assessment tasks



MOOC

- Learning Analytics
  - Based on learning activity data (Moodle)
  - Understand and improve learning

Goals and Research Questions

- Goals:
  - Develop a Moodle tool to help instructors and students monitoring learning progress
  - Derive a scientific and efficient method to predict student learning outcomes
- Research Questions
  - How a Moodle tool can be designed to help instructors and students monitor learning progress towards learning outcomes?
  - How can Moodle data be used to estimate student learning progress towards learning outcomes?

Learning Analytic Tool Design

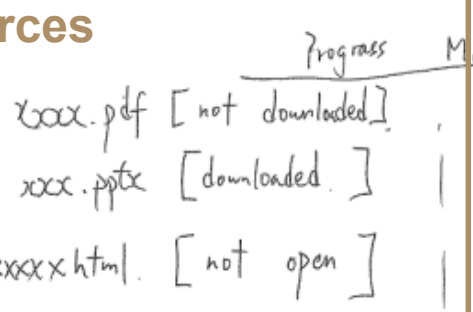
- Few studies in LA started from users' opinions
  - yet working with real users was effective for gaining insights into their needs in real-life scenarios
- Participatory Design
  - Active involvement of workplace practitioners in design
  - Can better fit the requirements and expectations of learners
  - Three focus groups (of 16 students)
    - Share ideas and allow ideas to converge
    - 1. Understanding and expectations of a monitoring tool for learning process towards outcomes
    - 2. Needs and requirements
    - 3. Draw a draft design
    - 4. Comment on a prepared generic design

Student Preferred Functions

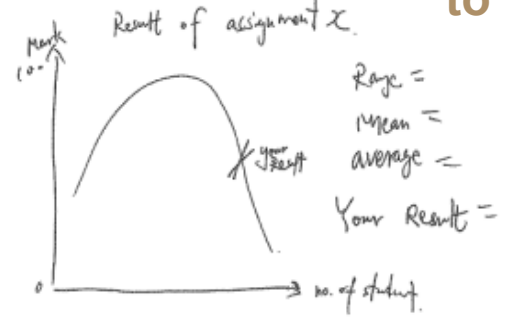
- Indicators of learning progress
  - Status of fulfillment of activities (both online and offline)
  - Activities lasting for long
    - Break into smaller activities
- Timeline-based functions
  - Reminders of deadlines
  - Differentiate finished activities and those due soon
- Peer comparison
  - Mixed opinions
    - +: Be informed of their positions in class
    - -: Too much pressure
    - -: Not important

Example Design from Students

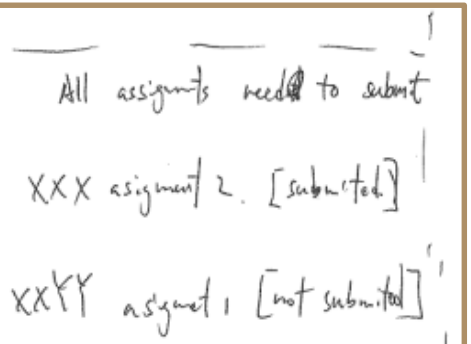
Status of Resources

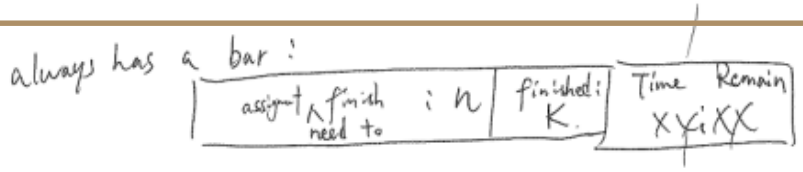


Comparison to the class



Status of Assignments





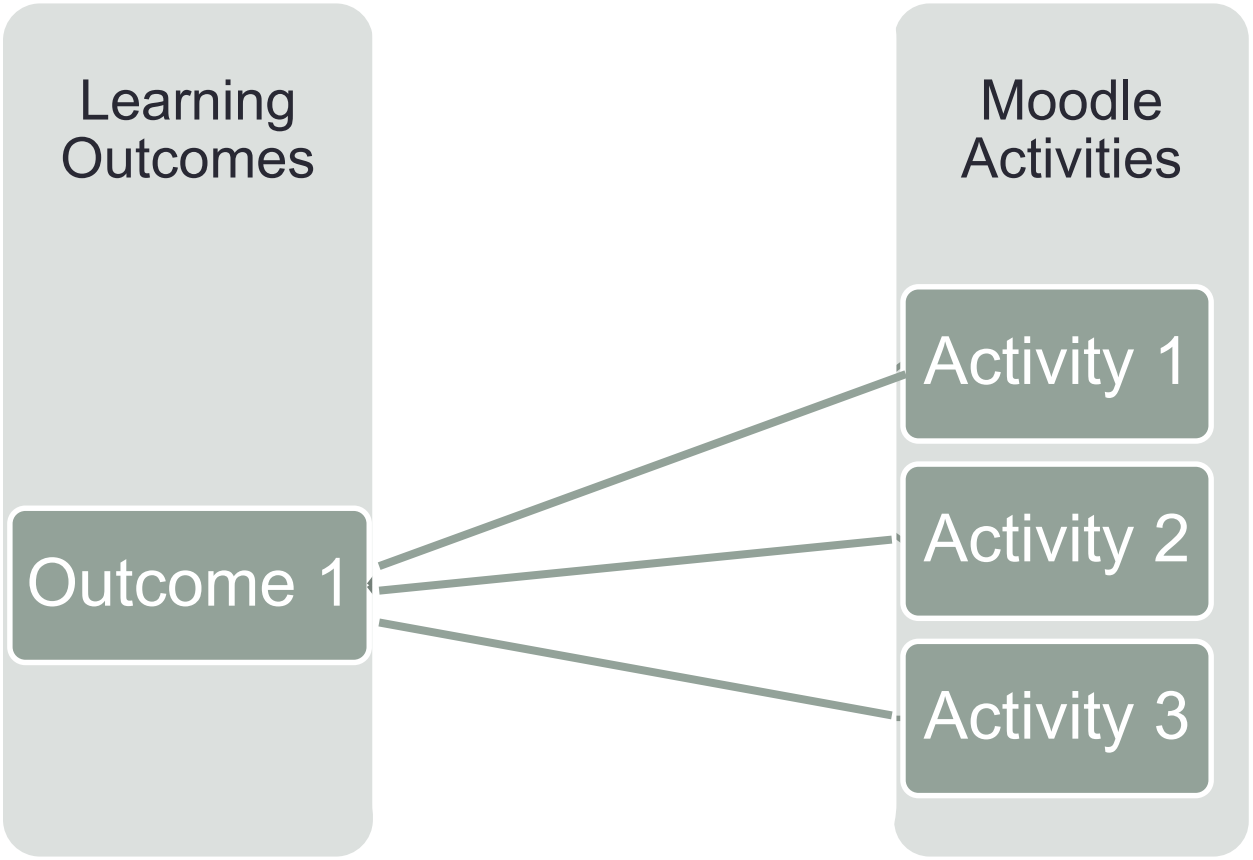
Timeline of tasks

Concerns from the Students

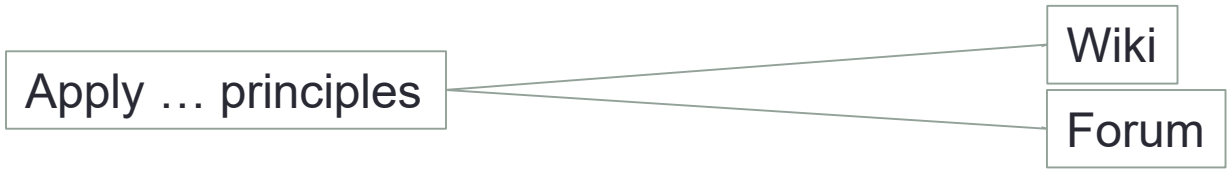
- Behaviors vs. Knowledge mastery and learning outcomes

- Misuse of evidence
  - What if overall progress of the class is slow?

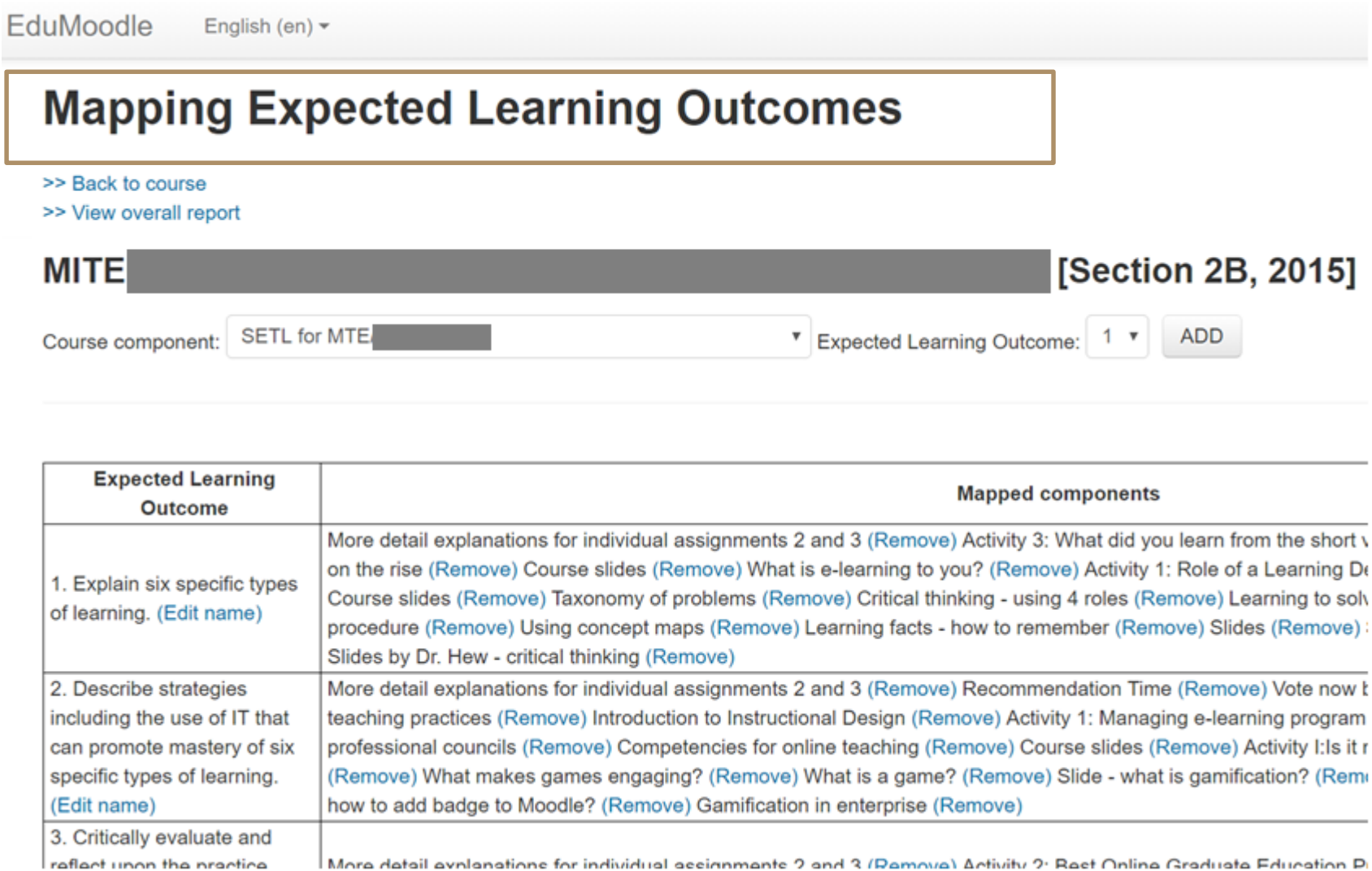
Linking Activities to Learning Outcomes



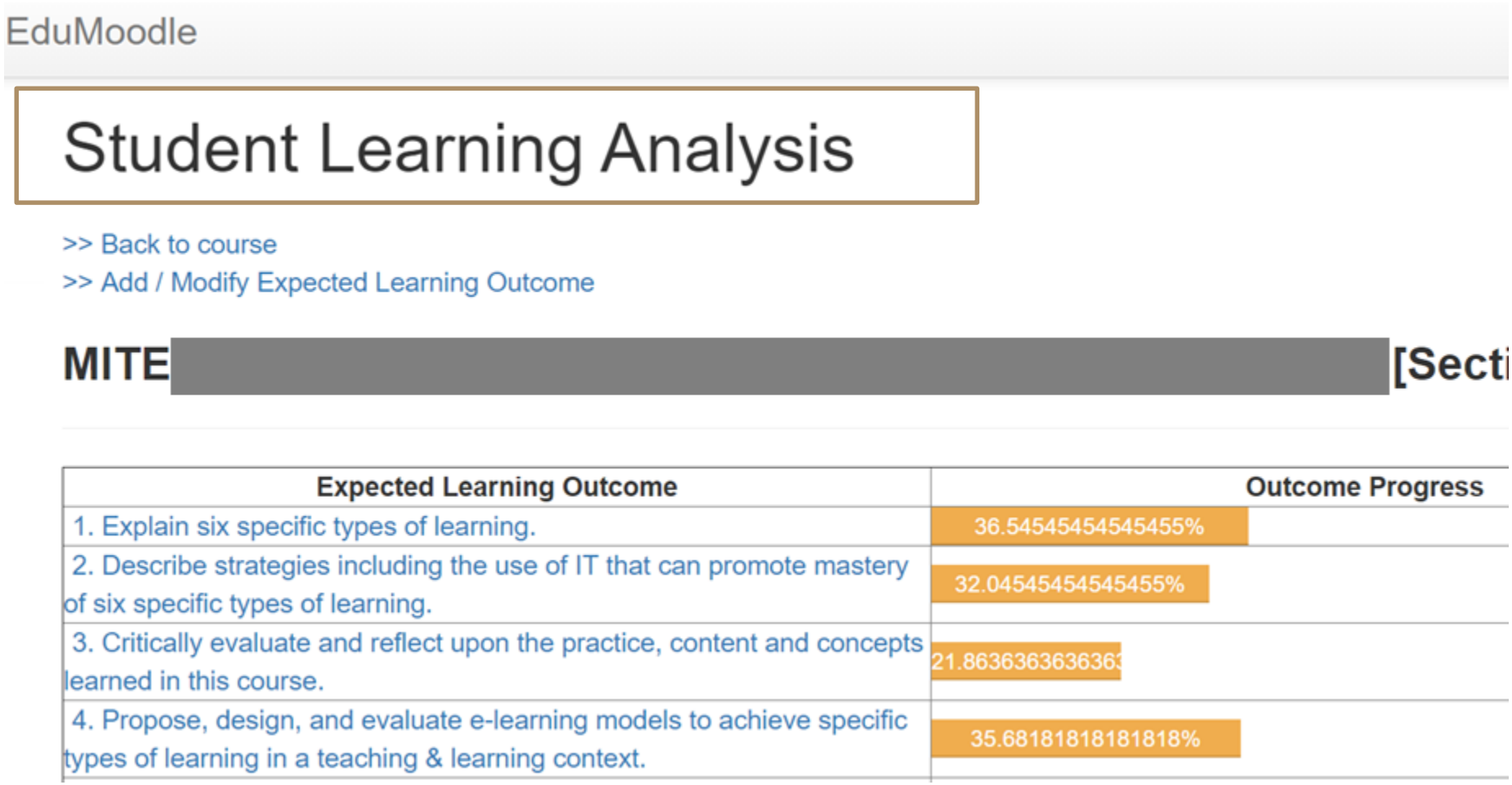
Activities:
- Forum
- Quiz
- Wiki
- Assignment
- Resources
- Feedback
- …



The Moodle Tool: instructor's view (1)

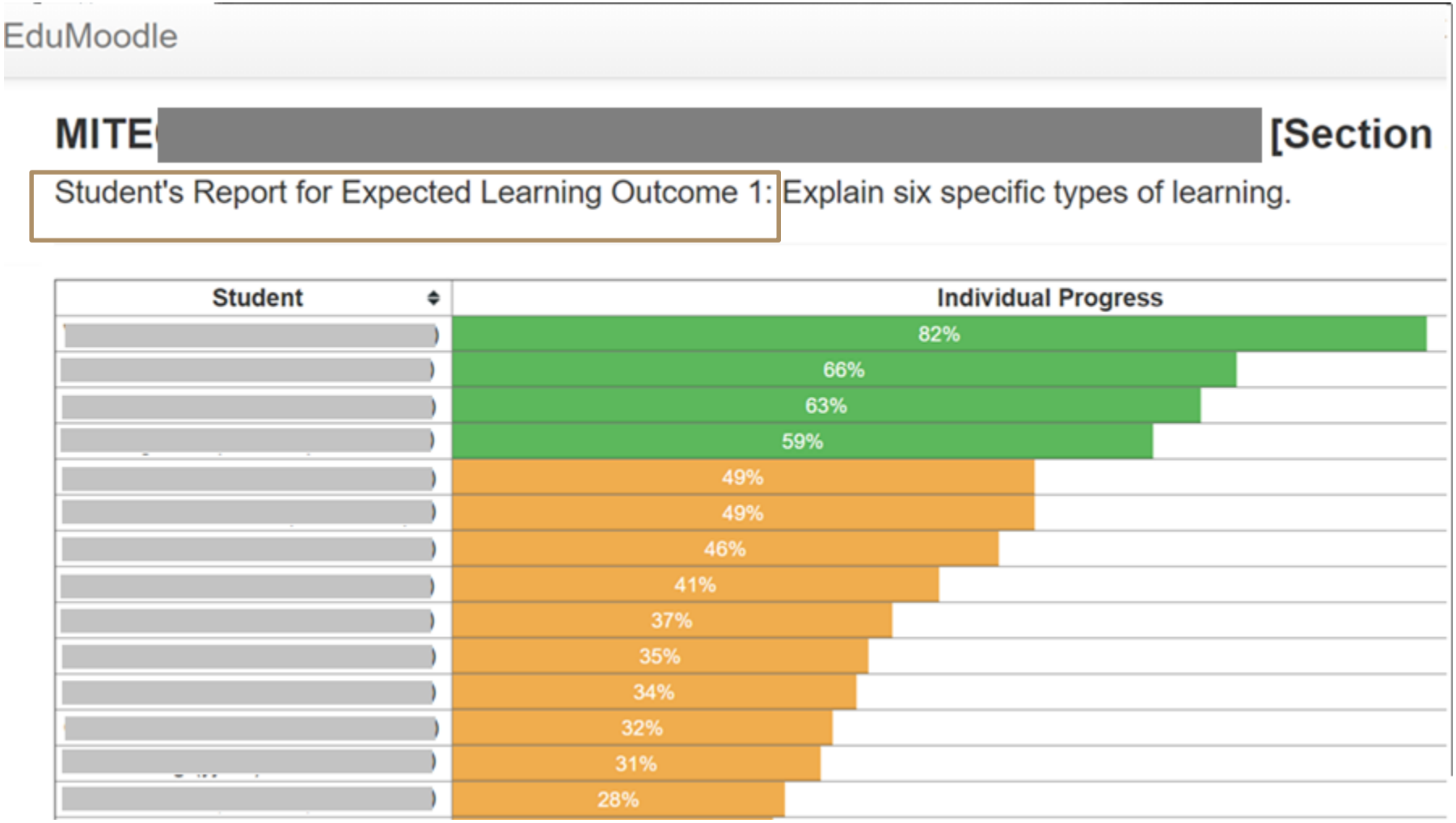


The Moodle Tool: instructor's view (2)



Expected Learning Outcome	Outcome Progress
1. Explain six specific types of learning.	36.54545454545455%
2. Describe strategies including the use of IT that can promote mastery of six specific types of learning.	32.04545454545455%
3. Critically evaluate and reflect upon the practice, content and concepts learned in this course.	21.8636363636363
4. Propose, design, and evaluate e-learning models to achieve specific types of learning in a teaching & learning context.	35.68181818181818%

The Moodle Tool: instructor's view (3)



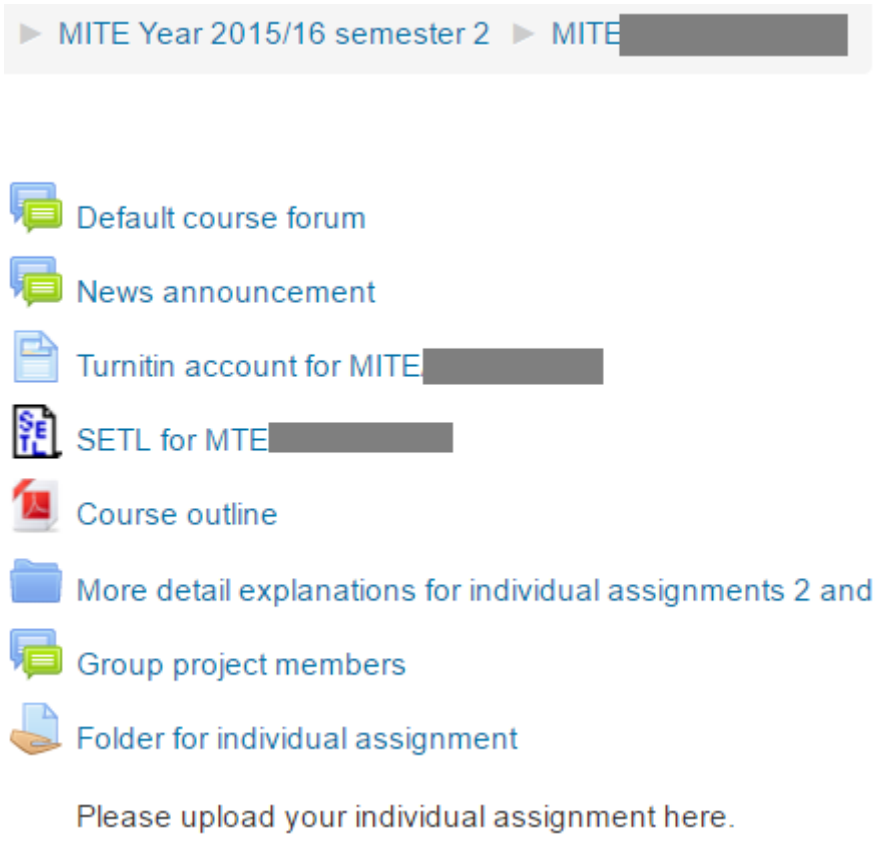
The Moodle Tool: student's view (1)

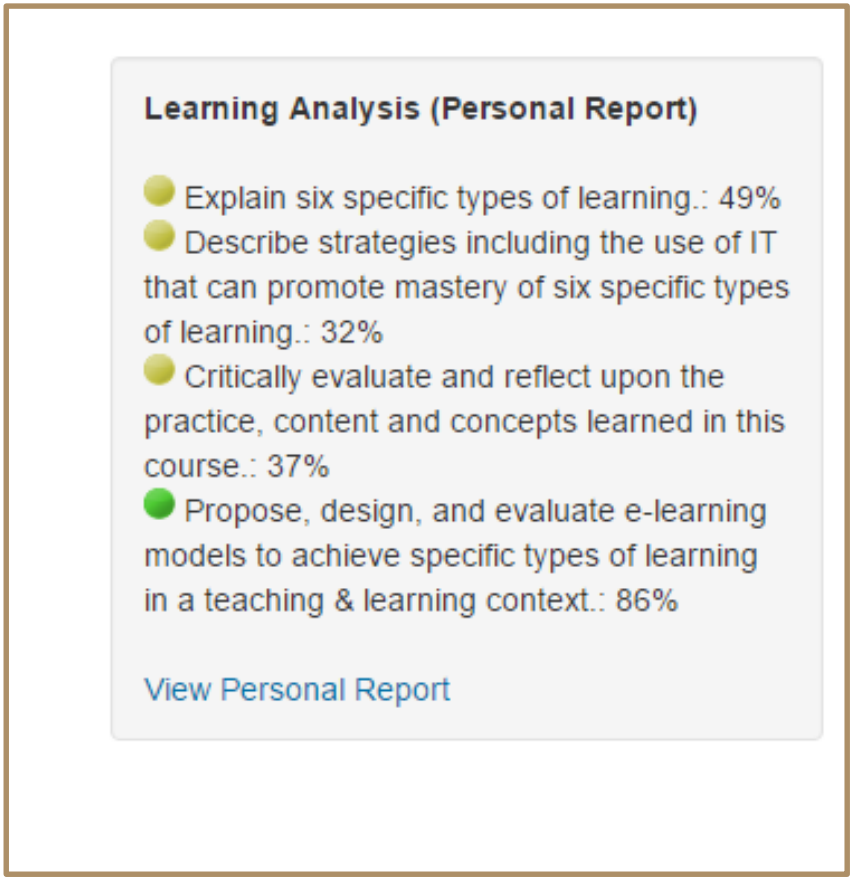
MITE [redacted] [Section 2B, 2015]

Personal Report for [redacted]

Expected Learning Outcome	Position with the class
Explain six specific types of learning.	
Describe strategies including the use of IT that can promote mastery of six specific types of learning.	
Critically evaluate and reflect upon the practice, content and concepts learned in this course.	
Propose, design, and evaluate e-learning models to achieve specific types of learning in a teaching & learning context.	
5	N/A
6	N/A
7	N/A

The Moodle Tool: student's view (2)





The Moodle Tool: Backend

- Currently still building the prediction model
- The numbers were calculated as engagement indicators
  - For each activity
    - Engagement count = count of actions on that activity in the logs
    - Upper boundary = 3rd quartile + 1.5*IQR (an outlier detection method)
    - Progress of a student = engagement count / upper boundary
  - For each outcome
    - Progress of a student = average of the progress on all activities related to the outcome
  - For overall progress of the class on an outcome
    - Average of individual progresses of all students in that outcome

Initial Evaluation of the Tool Prototype (1)

- Instructor
  - Helpful for monitoring student progress
  - Helpful for identifying at-risk students
  - Encourage instructor to focus on outcome-based learning
  - Support for evidence-based assessment (participation)
  - As it's automatic, especially good for large classes

  - Improvements:
    - Break down to activity level
    - Let the instructor to specify the weight of each activity for each outcome

Initial Evaluation of the Tool Prototype (2)

- Students
  - “Wow!”
  - “Definitely helpful for knowing where I am in the class”
  - Checking whether being “left behind”
  - More useful for courses with more Moodle activities
  - “If the instructor uses this tool, students would work harder”

  - Improvements:
    - Better explanation (which activities contribute to each outcome)
    - More sophisticated algorithms on some activities (“gaming the system”)

Prediction Models based on Moodle Data

- Study context: CCST9003 (Common Core)
- Two years' Moodle logs

Year	2013	2014
No. students	104	152
No. of log events	94K	151K

User	Time	Module	Action	URL	Info
10115	2013.9.27 9:30	course	view	?id=1234	CCST1234
10109	2013.9.29 19:15	forum	post	?id=203	Dis. forum
10101	2013.10.12 12:10	wiki	edit	?id=229	Group wiki

- 17 different modules: forum, quiz, wiki,…
- 53 types of actions: wiki view, add, update, post, edit,…

Predicting Performances (1)

- Predict student performances: overall and various assessment tasks
  - Homework; Quiz; Tutorial,…
- 90 module-action features/variables
  - Course-view; quiz-attempt, questionnaire-submit, ….
- Linear regression with stepwise backwards feature selection

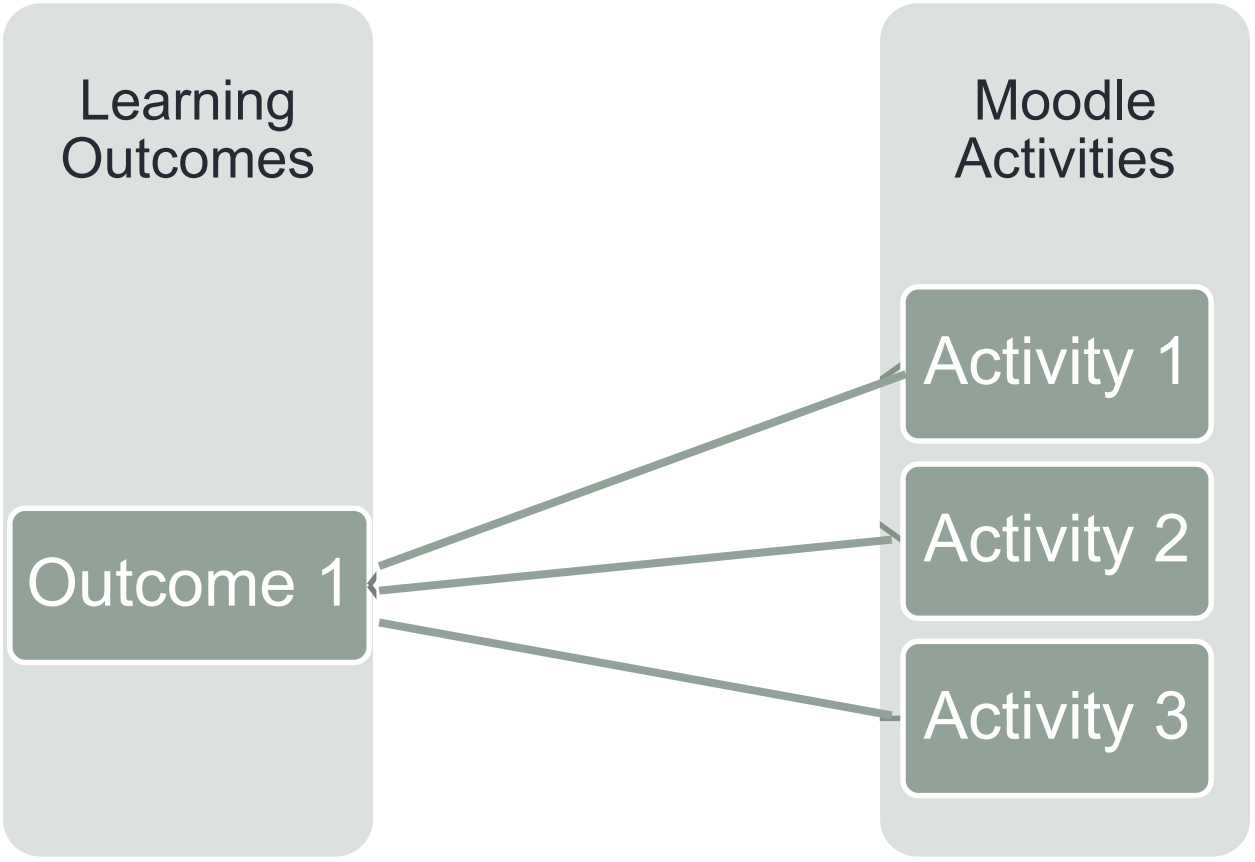
		Overall	Homework	Quiz	Tutorial	Group Wiki	Group Pres.	Indiv. Essay	Indiv. Pres.
2013 N = 104	No. of feat.	7	8	1	9	9	8	5	5
	R^2	0.43	0.40	0.37	0.15	0.25	0.21	0.09	0.12
2014 N= 152	No. of feat.	14	13	11	12	15	11	10	13
	R^2	0.66	0.54	0.59	0.33	0.40	0.36	0.23	0.24

Predicting Performances (2)

- Cross years
  - Using model built in 2013 to predict performances in 2014

R^2	Overall	Home work	Quiz	Tutorial	Group Wiki	Group Pres.	Indiv. Essay	Indiv. Pres.
2013 (all) -> 2014(all)	0.27	0.20	0.51	0.05	0.02	0.02	0.00	0.04
2013 (all) -> 2014(midterm)	0.43	0.37	0.46	0.09	0.08	0.05	0.09	0.11
2013 (all) -> 2014(1st Q)	0.31	0.23	0.29	0.18	0.09	0.07	0.12	0.08
2013 (mid) -> 2014(all)	**0.51**	**0.45**	**0.48**	0.18	0.14	0.12	0.10	0.08
2013 (mid) -> 2014(midterm)	0.43	0.36	0.39	0.08	0.06	0.09	0.12	0.08
2013 (mid) -> 2014(1st Q)	0.26	0.26	0.26	0.08	0.04	0.08	0.13	0.08

Predicting Performances of Moodle "Activities"



Activities:

- Forum
- Quiz
- Wiki
- Assignment
- Resources
- Feedback
- …

Apply … principles

Wiki

Forum

“Activity”-based Features: Quiz

Feature name	Description
Attempts	Total number of attempts taken for one take-home quiz.
First attempt start time	The start time of first submitted attempt.
First attempt finish time	The finish time of first submitted attempt.
First attempt duration	Duration of a student first submitted attempt.
Last attempt start time	The start time of last submitted attempt.
Last attempt finish time	The finish time of last submitted attempt.
Last attempt duration	Duration of a student last submitted attempt.
Quiz review	Total number of ‘quiz review’ taken before quiz due.
Quiz close attempt	Total number of ‘quiz close attempt’ taken before due.
Quiz attempt	Total number of ‘quiz attempt’ taken before quiz due.
Quiz view summary	Total number of ‘quiz view summary’ taken before due.
Quiz continue attempt	Total number of ‘quiz continue attempt’ taken before due.
Quiz view	Total number of ‘quiz view’ a student taken before due.
.....	

“Activity”-based Features: Wiki

Feature	Description
Log total	Total number of logs before the group wiki project due.
Wiki history	Total number of ‘wiki history’ a student taken before wiki due.
Wiki edit	Total number of ‘wiki edit’ a student taken before wiki due.
Wiki map	Total number of ‘wiki map’ a student taken before wiki due.
Wiki comments	Total number of ‘wiki comments’ taken before wiki due.
Wiki diff	Total number of ‘wiki diff’ a student taken before wiki due.
Wiki comment	Total number of ‘wiki comment’ taken before wiki due.
Wiki restore	Total number of ‘wiki restore a student taken before wiki due.
Wiki add page	Total number of ‘wiki add page’ a taken before wiki due.
Wiki view	Total number of ‘wiki view’ a student taken before wiki due.

Regression vs. Classification

- Linear regression with stepwise backwards feature selection

		Multi-attempt Quiz	Single-attempt Quiz	Wiki	Assignment
2013 N = 104	No. of feat.	8	3	1	1
	R^2	0.21	0.10	0.08	0.06

- Classification: detect "at-risk" students
  - "At-risk" = performance below average
  - Models
    - LASSO: good interpretability
    - SVM: good performances

Classification Results

Training on 2013 data; Testing on 2014 data

		Multi-attempt Quiz	Single-attempt Quiz	Wiki
LASSO	Accuracy	0.55	0.54	0.57
	FP (error rate)	0.26	0.22	0.43
	FN (error rate)	**0.19**	**0.24**	**0**
SVM (rbf)	Accuracy	**0.62**	**0.63**	**0.61**
	FP (error rate)	0.26	0.27	0.23
	FN (error rate)	**0.11**	**0.10**	**0.16**

FN: false negative: “at-risk” students predicted as normal

Summary

- Goals: develop a Moodle tool for monitoring and prediction
- Methods:
  - Participatory and iterative design
  - Classroom evaluation (to do)
  - Prediction: regression and classification
- Significance: LA connected to learning and teaching
  - More Moodle activities
  - Outcome-based learning
  - Evidence-based assessment
  - Sustainable feedback

Discussion (Challenges)

- Monitoring tool for ***blended*** courses
  - What about offline activities?
- Outcome-based analytics
  - Engagement vs. Performances?
  - Outcome-based assessment?
- Predicting **assessment task** performances
  - Some tasks can be predicted across years
  - May not be generalizable across courses, or different designs of the same course
- Predicting **Moodle activity** performances
  - Potentially generalizable across courses
  - May be challenging to obtain accurate models

THANK YOU !
APPRECIATE COMMENTS & SUGGESTIONS

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