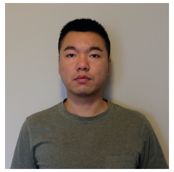
This paper is based upon work supported by the National Science Foundation under Grant No. 1755910.

UNIVERSITY AT ALBANY
State University of New York

Modeling Knowledge Acquisition from Multiple Learning Resource Types

 Siqian Zhao  Chunpai Wang  Shaghayegh (Sherry) Sahebi

Presented By Siqian Zhao (szhao2@Albany.edu)

EDM 2020: the 13th International Conference on Educational Data Mining

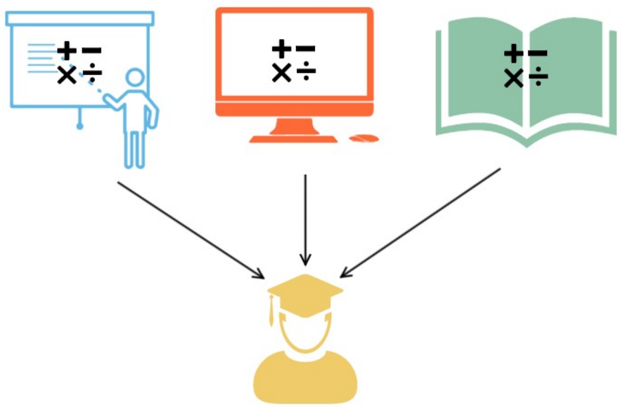
Content

University at Albany
State University of New York

- Introduction
- Model
- Experiments
- Conclusions

Introduction

- Motivation
  - Student knowledge modeling and domain knowledge modeling are important
    - Creating a coherent study plan,
    - Modeling students‘ knowledge,
    - Analyzing students' knowledge gaps
  - Ideally:
    - Student can learn from multiple types of learning materials
    - Relationships between various kinds of learning materials



Introduction

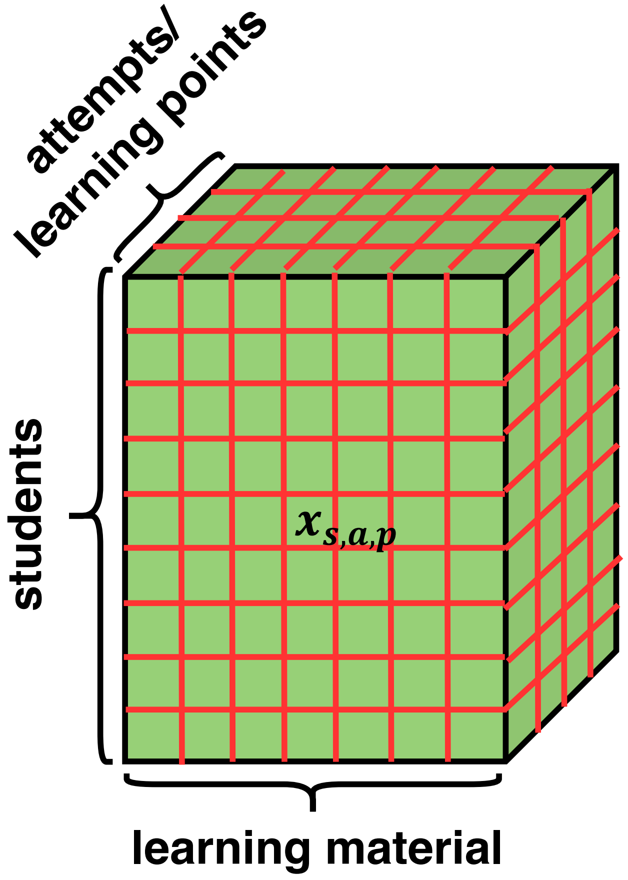
- Contribution
  - Propose a multi-view student knowledge model (MVKM)
  - Outperform on both synthetic and real-world datasets
  - Capture similarity between learning material types
  - Represent student knowledge

Model

- Problem formulation
- MVKM-Factorization part
- MVKM-Rank based constraint

Problem formulation

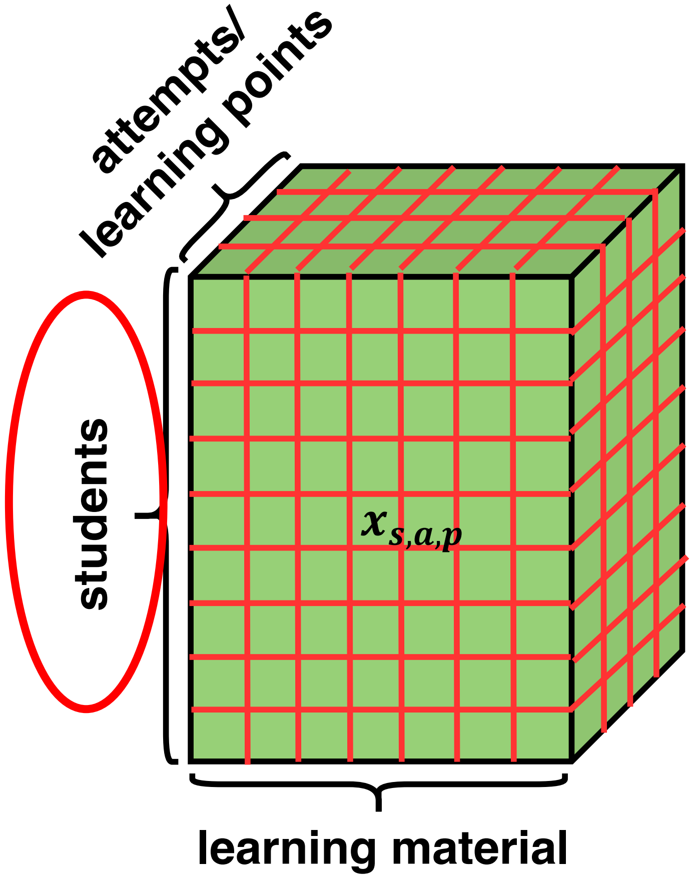
- Interactions of each learning material type - one tensor



Problem formulation

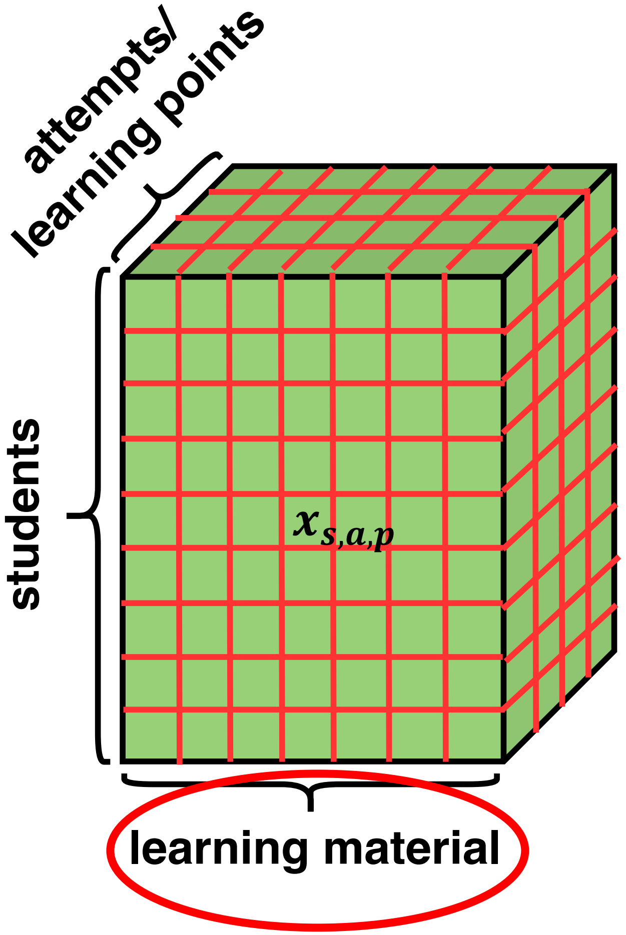
UNIVERSITY AT ALBANY
State University of New York

- Interactions of each learning material type - one tensor



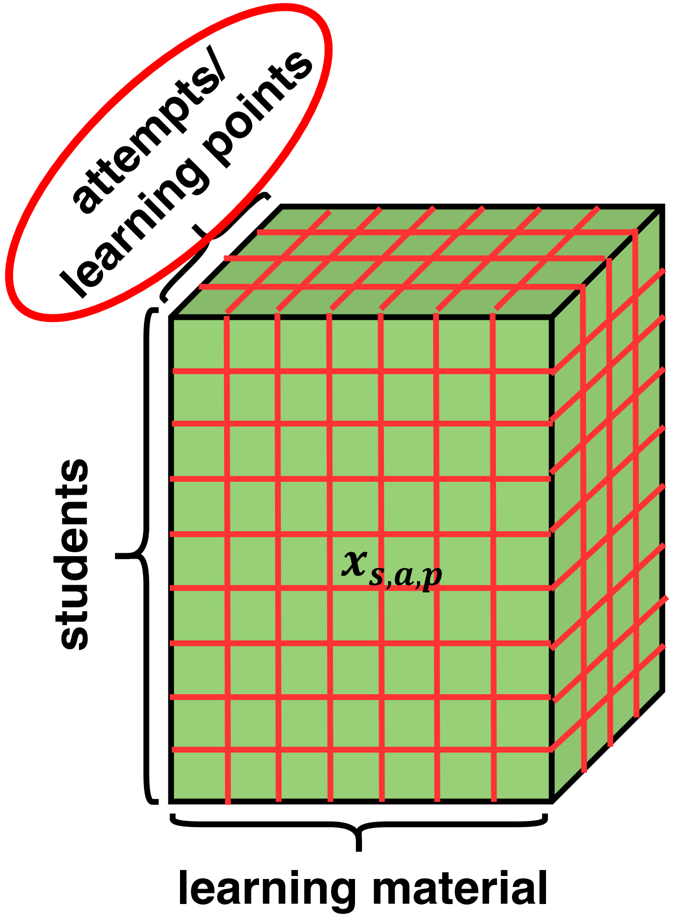
Problem formulation

- Interactions of each learning material type - one tensor



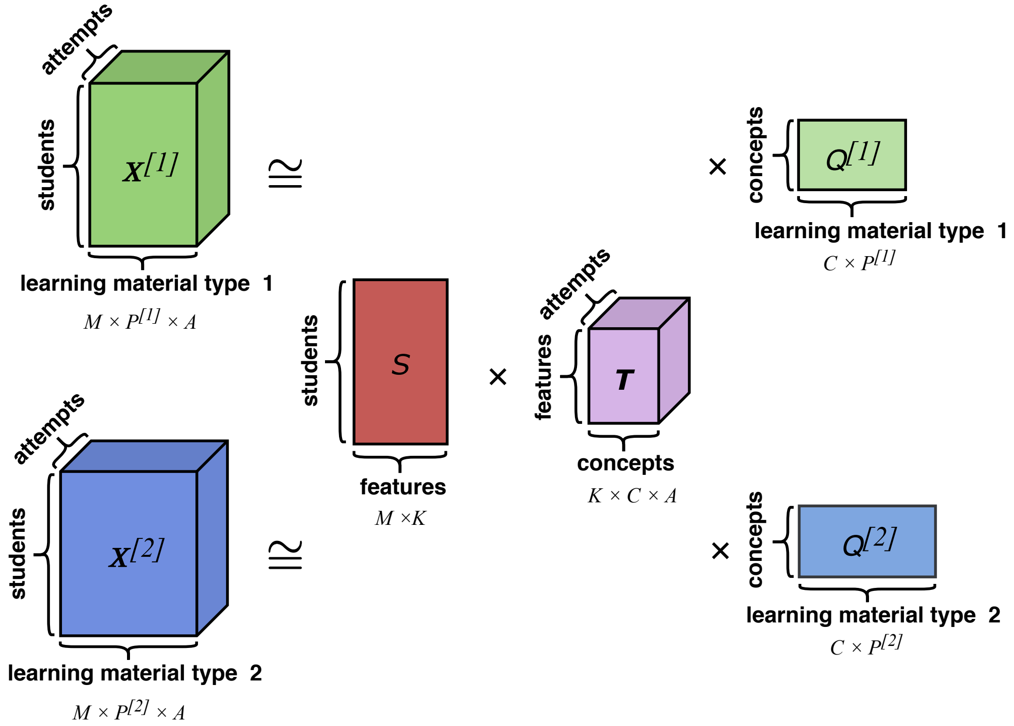
Problem formulation

- Interactions of each learning material type - one tensor



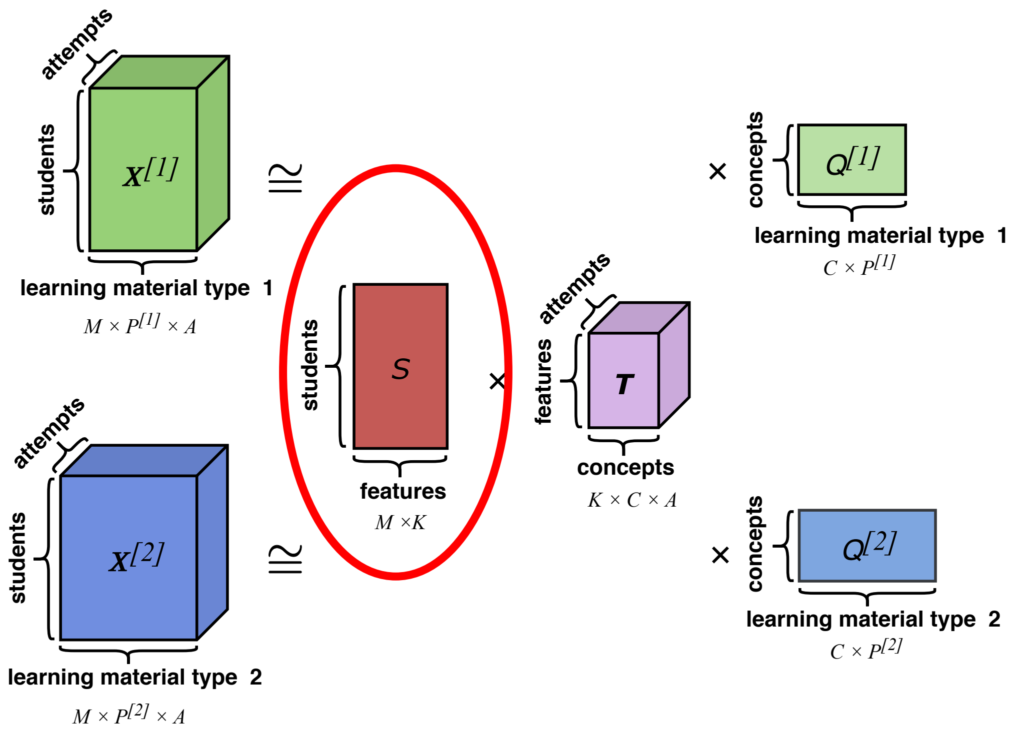
MVKM-Factorization

- Interactions of each learning material type - one tensor



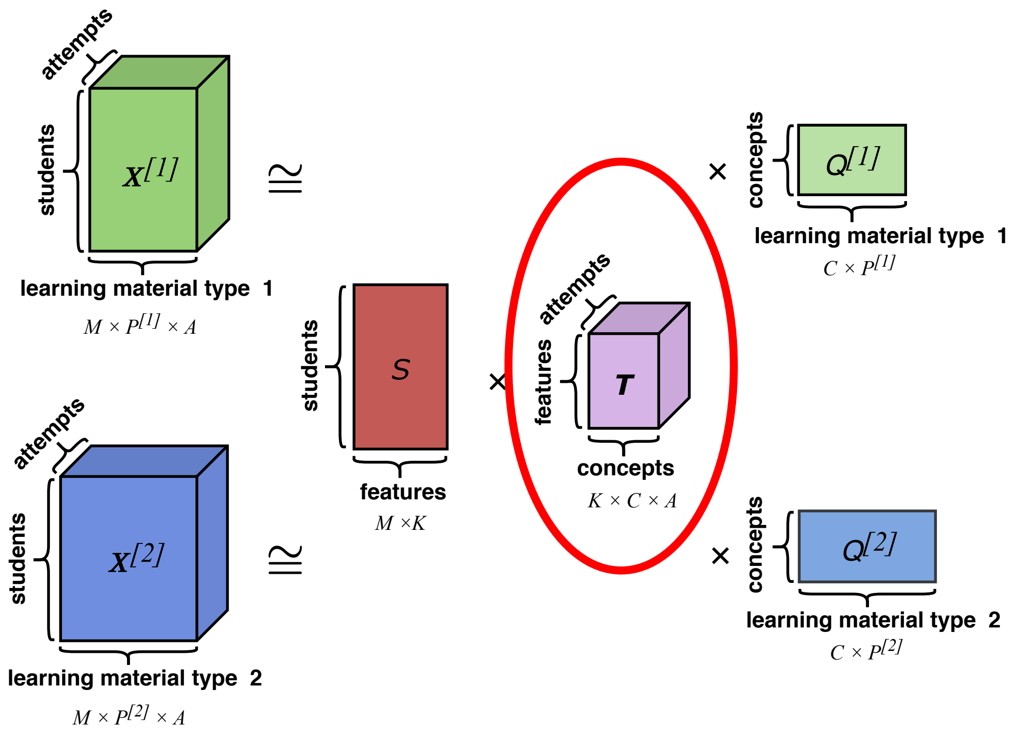
MVKM-Factorization

- Interactions of each learning material type - one tensor



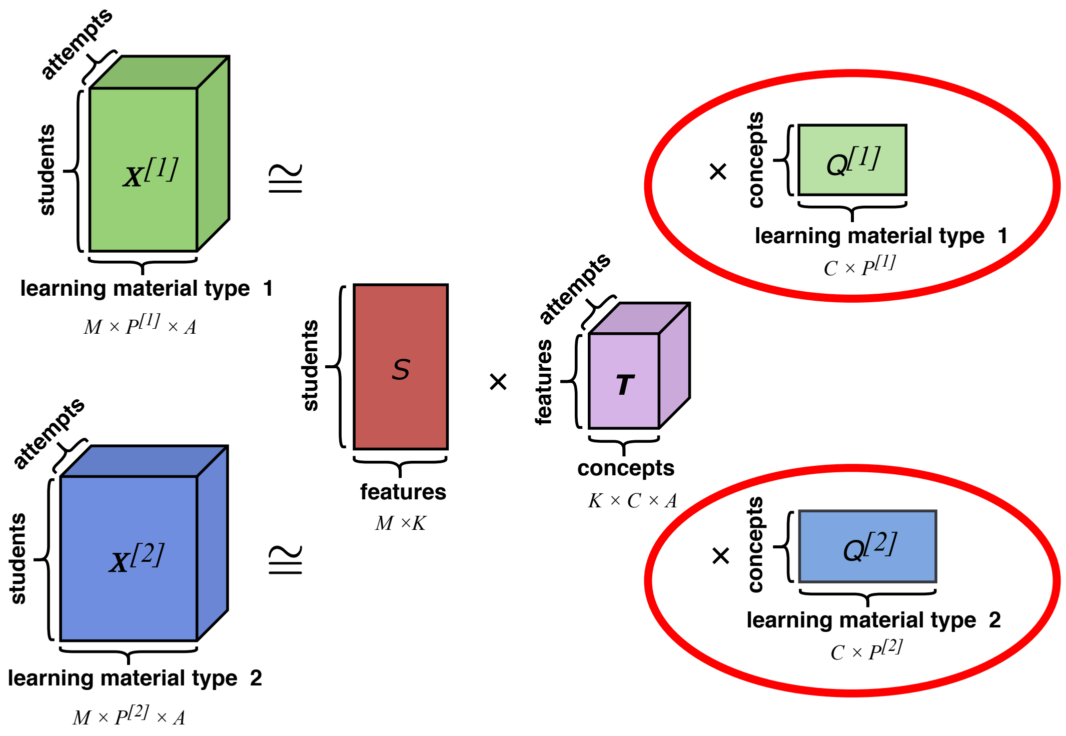
MVKM-Factorization

- Interactions of each learning material type - one tensor



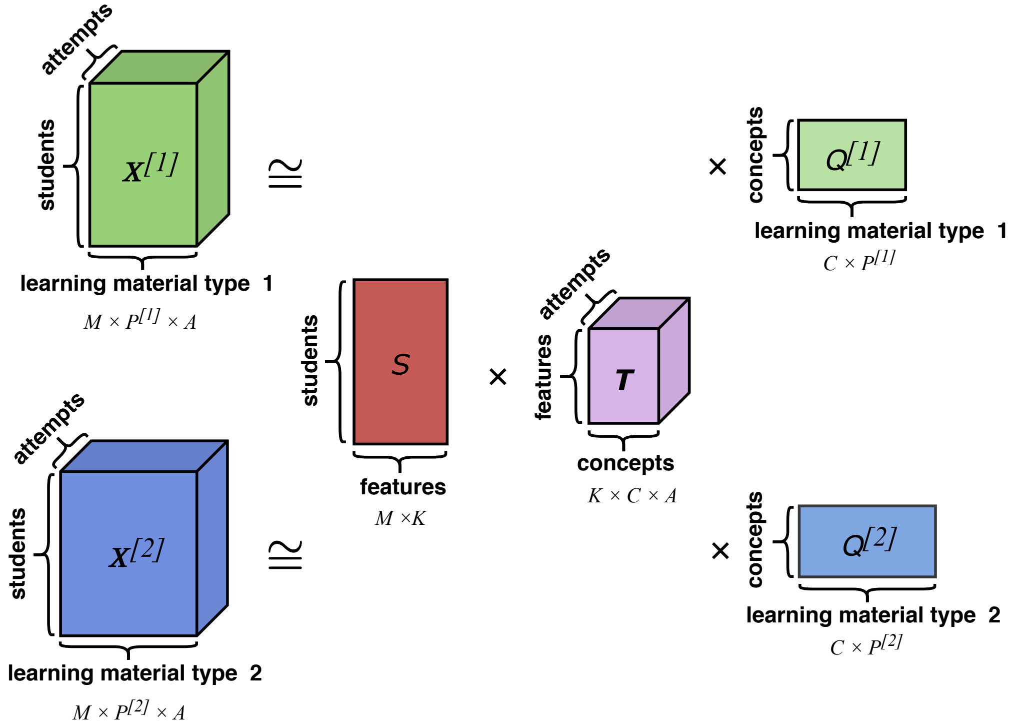
MVKM-Factorization

- Interactions of each learning material type - one tensor



MVKM-Factorization

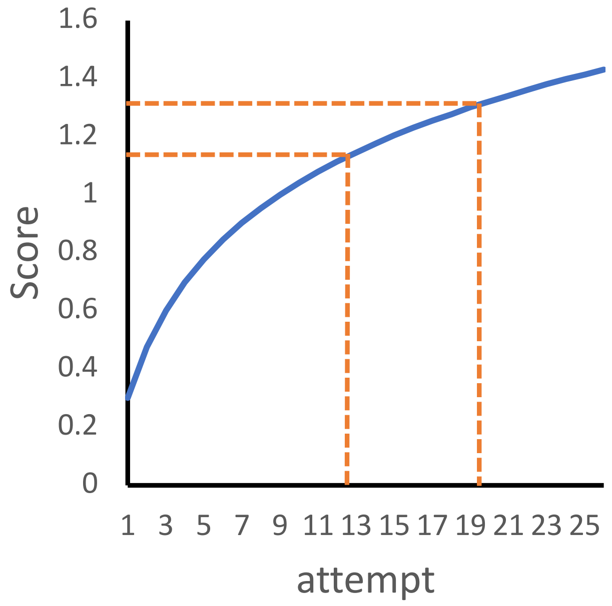
- Interactions of each learning material type - one tensor



$$\hat{x}_{s,a,p}^{[r]} \approx \boldsymbol{s}_s \cdot T_a \cdot \boldsymbol{q}_p^{[r]} + \overbrace{b_s + b_p^{[r]} + b_a}^{\text{biases}}$$

MVKM-Rank based constraint

- Students' knowledge increase



$$\boldsymbol{s}_s \cdot T_{a+1} \cdot \boldsymbol{q}_p^{[r]} - \boldsymbol{s}_s \cdot T_a \cdot \boldsymbol{q}_p^{[r]} \geq 0$$

Experiments

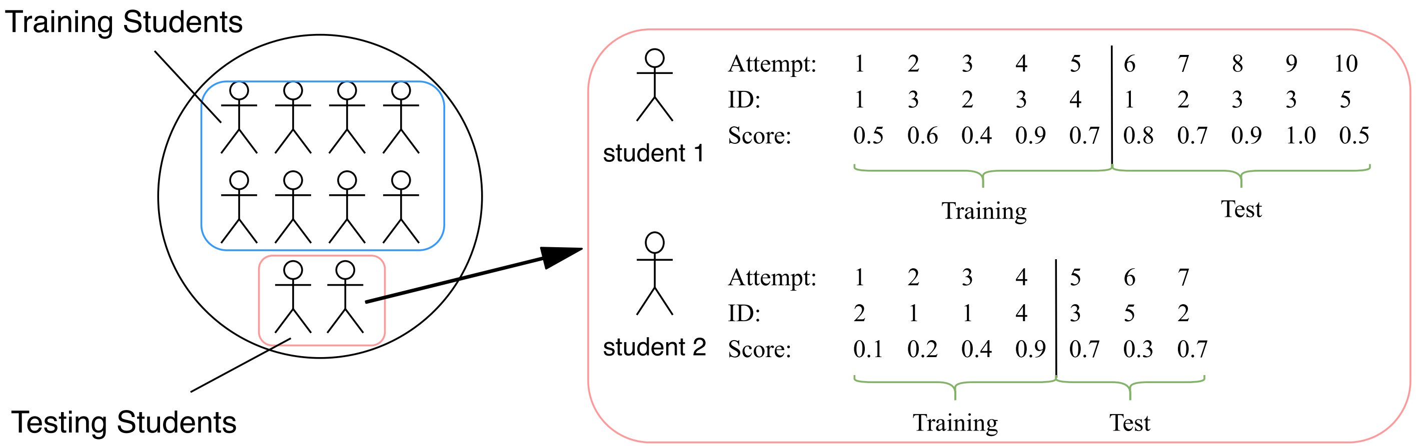
- We evaluate our model with three sets of experiments:
  - **Student Performance Prediction -** to validate if the model captures the variability of observed data
  - **Student Knowledge Modeling -** to check if our model represents valid student knowledge growth
  - **Learning Resource Modeling -** to study if the model meaningfully recovers learning materials' latent concepts

Datasets & Experiment Setup

- Datasets
  - Three synthetic datasets
  - Canvas Network Platform
  - MOOC Replication Framework (MORF)
- Experiment Setup
  - We use 5-fold student stratified cross-validation

Dataset	material type 1 (#)	material type 2 (#)	#stu	act. seq. len.	#rcds.	avg. sco.
Synthetic_NG	quiz (10)	discussion (15)	1000	20	19991	0.6230
Synthetic_NG2	quiz (10)	discussion (15)	1000	20	19991	0.6984
Synthetic_G	quiz (10)	assignment (15)	1000	20	19980	0.6255
MORF_QD	assignment (18)	discussion (525)	459	25	6800	0.8693
MORF_QL	assignment (10)	lecture (52)	1329	76	58956	0.7731
Canvas_H	quiz (10)	discussion (43)	1091	20	13633	0.8648

Statistics for each datasets



Baselines & Metrics

- Baselines
  - Educational Data mining: **IBKT, DKT, FDTF, TFWL, RBTF**
  - Recommendation System**: BPTF**
  - Different settings of proposed model
    - **MVKM-Base**: MVKM with single learning material type
    - **MVKM-W /O-P**: MVKM without knowledge increase constraint
  - **[method name]-MV**: Baselines ‘Multiview’ setting
  - **AVG**
- Metrics
  - Root Mean Squared Error (RMSE)
  - Mean Absolute Error (MAE)

Does MVKM outperform other baselines?

UNIVERSITY AT ALBANY
State University of New York

Methods	Synthetic_NG		Synthetic_NG2		Synthetic_G	
	RMSE	MAE	RMSE	MAE	RMSE	MAE
AVG	0.3084±0.0072	0.2820±0.0093	0.5059±0.0115	0.4005±0.0115	0.3070±0.0039	0.2811±0.0050
RBTF	0.2515±0.0126	0.2027±0.0081	0.3374±0.0234	0.2681±0.0146	0.2628±0.0113	0.2103±0.0080
FDTF	0.4906±0.0172	0.4410±0.0207	0.6588±0.0215	0.5529±0.0226	0.5041±0.0184	0.4537±0.0213
TFWL	0.5283±0.0168	0.4632±0.0178	0.6919±0.0132	0.5883±0.0156	0.5490±0.0053	0.5130±0.0076
BPTF	0.1675±0.0048	0.1256±0.0061	0.3454±0.0140	0.2589±0.0072	0.1825±0.0064	0.1381±0.0050
IBKT	0.4744±0.0118	0.4197±0.0140	0.6630±0.0122	0.5494±0.0152	0.4748±0.0076	0.4233±0.0098
DKT	0.2694±0.0275	0.1911±0.0241	0.4536±0.0404	0.3569±0.0413	0.2716±0.0209	0.2047±0.0178
RBTF-MV	0.2920±0.0069	0.2305±0.0078	0.4064±0.0213	0.3227±0.0147	0.2618±0.0155	0.2126±0.0130
FDTF-MV	0.4078±0.0168	0.3402±0.0167	0.5861±0.0211	0.4688±0.0135	0.4888±0.0112	0.4538±0.0131
TFWL-MV	0.4337±0.0139	0.3896±0.0133	0.6386±0.0161	0.5450±0.0194	0.5312±0.0137	0.4626±0.0145
BPTF-MV	0.1718±0.0037	0.1457±0.0055	0.3438±0.0158	0.2603±0.0120	0.1533±0.0055	0.1184±0.0044
IBKT-MV	0.4257±0.0142	0.3585±0.0155	0.6019±0.0124	0.4892±0.0165	0.4844±0.0068	0.4275±0.0089
DKT-MV	0.4278±0.0313	0.3613±0.0318	0.6399±0.0515	0.5320±0.0526	0.3390±0.0252	0.2892±0.0245
MVKM-Base	0.2007±0.1069	0.1498±0.0809	0.3026±0.0697	0.2273±0.0356	0.2097±0.0485	0.1565±0.0348
MVKM-W /O-P	0.1714±0.0089	0.1306±0.0089	0.2817±0.0316	0.2213±0.0245	0.1796±0.0345	0.1357±0.0190
Our Method (MVKM)	**0.1388±0.0048**	**0.1049±0.0056**	**0.2221±0.0074**	**0.1739±0.0048**	**0.1532±0.0128**	**0.1171±0.0097**

Performance Prediction results on synthetic datasets

Methods	MORF_QD		MORF_QL		CANVAS_H	
	RMSE	MAE	RMSE	MAE	RMSE	MAE
AVG	0.2410±0.0227	0.1913±0.0161	0.2420±0.0108	0.1957±0.0067	0.0767±0.0121	0.0555±0.0040
RBTF	0.2711±0.0229	0.2132±0.0147	0.2572±0.0114	0.1980±0.0074	0.1571±0.0172	0.1235±0.0103
FDTF	0.3081±0.0437	0.2401±0.0329	0.3006±0.0194	0.2324±0.0151	0.1395±0.0259	0.0929±0.0119
TFWL	0.2750±0.0529	0.2003±0.0249	0.3090±0.3090	0.2237±0.0099	0.2377±0.0803	0.1186±0.0513
BPTF	0.2172±0.0128	0.1776±0.0082	0.2302±0.0068	0.1953±0.0048	0.1114±0.0120	0.0946±0.0082
IBKT	0.2756±0.0070	0.2281±0.0053	0.2646±0.0147	0.2174±0.0096	0.0856±0.0105	0.0692±0.0042
DKT	0.3169±0.0374	0.2498±0.0313	0.2859±0.0061	0.2158±0.0075	0.0911±0.0322	0.0616±0.0173
RBTF-MV	0.2814±0.0282	0.2177±0.0222	0.2624±0.0193	0.1977±0.0136	0.1484±0.0098	0.1171±0.0054
FDTF-MV	0.3138±0.0441	0.2453±0.0387	0.2398±0.0137	0.1866±0.0091	0.1149±0.0085	0.0907±0.0068
TFWL-MV	0.2919±0.0275	0.1975±0.0160	0.3222±0.0208	0.2178±0.0165	0.1748±0.0600	0.0784±0.0269
BPTF-MV	0.2615±0.0129	0.2286±0.0114	0.2313±0.0070	0.1960±0.0041	0.1452±0.0100	0.1343±0.0081
IBKT-MV	0.2774±0.0204	0.2177±0.0099	0.2904±0.0098	0.2137±0.0062	0.0834±0.0125	0.0425±0.0049
DKT-MV	0.2938±0.0310	0.2352±0.0236	0.2540±0.0065	0.2185±0.0047	0.079±0.0247	0.0496±0.0065
MVKM-Base	0.2242±0.0328	0.1669±0.0207	0.2277±0.0119	0.1724±0.0081	0.0666±0.0159	0.0411±0.0040
MVKM-W /O-P	0.2385±0.0196	0.1771±0.0104	0.2450±0.0145	0.1814±0.009	0.0649±0.0111	0.0388±0.0027
Our Method (MVKM)	**0.2088±0.0229**	**0.1603±0.0142**	**0.2150±0.0127**	**0.1654±0.0104**	**0.0613±0.0112**	**0.0362±0.0028**

Performance Prediction results on real datasets

Does MVKM outperform other baselines?

UNIVERSITY AT ALBANY
State University of New York

Yes!

Methods	Synthetic_NG		Synthetic_NG2		Synthetic_G	
	RMSE	MAE	RMSE	MAE	RMSE	MAE
AVG	0.3084±0.0072	0.2820±0.0093	0.5059±0.0115	0.4005±0.0115	0.3070±0.0039	0.2811±0.0050
RBTF	0.2515±0.0126	0.2027±0.0081	0.3374±0.0234	0.2681±0.0146	0.2628±0.0113	0.2103±0.0080
FDTF	0.4906±0.0172	0.4410±0.0207	0.6588±0.0215	0.5529±0.0226	0.5041±0.0184	0.4537±0.0213
TFWL	0.5283±0.0168	0.4632±0.0178	0.6919±0.0132	0.5883±0.0156	0.5490±0.0053	0.5130±0.0076
BPTF	0.1675±0.0048	0.1256±0.0061	0.3454±0.0140	0.2589±0.0072	0.1825±0.0064	0.1381±0.0050
IBKT	0.4744±0.0118	0.4197±0.0140	0.6630±0.0122	0.5494±0.0152	0.4748±0.0076	0.4233±0.0098
DKT	0.2694±0.0275	0.1911±0.0241	0.4536±0.0404	0.3569±0.0413	0.2716±0.0209	0.2047±0.0178
RBTF-MV	0.2920±0.0069	0.2305±0.0078	0.4064±0.0213	0.3227±0.0147	0.2618±0.0155	0.2126±0.0130
FDTF-MV	0.4078±0.0168	0.3402±0.0167	0.5861±0.0211	0.4688±0.0135	0.4888±0.0112	0.4538±0.0131
TFWL-MV	0.4337±0.0139	0.3896±0.0133	0.6386±0.0161	0.5450±0.0194	0.5312±0.0137	0.4626±0.0145
BPTF-MV	0.1718±0.0037	0.1457±0.0055	0.3438±0.0158	0.2603±0.0120	0.1533±0.0055	0.1184±0.0044
IBKT-MV	0.4257±0.0142	0.3585±0.0155	0.6019±0.0124	0.4892±0.0165	0.4844±0.0068	0.4275±0.0089
DKT-MV	0.4278±0.0313	0.3613±0.0318	0.6399±0.0515	0.5320±0.0526	0.3390±0.0252	0.2892±0.0245
MVKM-Base	0.2007±0.1069	0.1498±0.0809	0.3026±0.0697	0.2273±0.0356	0.2097±0.0485	0.1565±0.0348
MVKM-W /O-P	0.1714±0.0089	0.1306±0.0089	0.2817±0.0316	0.2213±0.0245	0.1796±0.0345	0.1357±0.0190
Our Method (MVKM)	**0.1388±0.0048**	**0.1049±0.0056**	**0.2221±0.0074**	**0.1739±0.0048**	**0.1532±0.0128**	**0.1171±0.0097**

Performance Prediction results on synthetic datasets

Methods	MORF_QD		MORF_QL		CANVAS_H	
	RMSE	MAE	RMSE	MAE	RMSE	MAE
AVG	0.2410±0.0227	0.1913±0.0161	0.2420±0.0108	0.1957±0.0067	0.0767±0.0121	0.0555±0.0040
RBTF	0.2711±0.0229	0.2132±0.0147	0.2572±0.0114	0.1980±0.0074	0.1571±0.0172	0.1235±0.0103
FDTF	0.3081±0.0437	0.2401±0.0329	0.3006±0.0194	0.2324±0.0151	0.1395±0.0259	0.0929±0.0119
TFWL	0.2750±0.0529	0.2003±0.0249	0.3090±0.3090	0.2237±0.0099	0.2377±0.0803	0.1186±0.0513
BPTF	0.2172±0.0128	0.1776±0.0082	0.2302±0.0068	0.1953±0.0048	0.1114±0.0120	0.0946±0.0082
IBKT	0.2756±0.0070	0.2281±0.0053	0.2646±0.0147	0.2174±0.0096	0.0856±0.0105	0.0692±0.0042
DKT	0.3169±0.0374	0.2498±0.0313	0.2859±0.0061	0.2158±0.0075	0.0911±0.0322	0.0616±0.0173
RBTF-MV	0.2814±0.0282	0.2177±0.0222	0.2624±0.0193	0.1977±0.0136	0.1484±0.0098	0.1171±0.0054
FDTF-MV	0.3138±0.0441	0.2453±0.0387	0.2398±0.0137	0.1866±0.0091	0.1149±0.0085	0.0907±0.0068
TFWL-MV	0.2919±0.0275	0.1975±0.0160	0.3222±0.0208	0.2178±0.0165	0.1748±0.0600	0.0784±0.0269
BPTF-MV	0.2615±0.0129	0.2286±0.0114	0.2313±0.0070	0.1960±0.0041	0.1452±0.0100	0.1343±0.0081
IBKT-MV	0.2774±0.0204	0.2177±0.0099	0.2904±0.0098	0.2137±0.0062	0.0834±0.0125	0.0425±0.0049
DKT-MV	0.2938±0.0310	0.2352±0.0236	0.2540±0.0065	0.2185±0.0047	0.079±0.0247	0.0496±0.0065
MVKM-Base	0.2242±0.0328	0.1669±0.0207	0.2277±0.0119	0.1724±0.0081	0.0666±0.0159	0.0411±0.0040
MVKM-W /O-P	0.2385±0.0196	0.1771±0.0104	0.2450±0.0145	0.1814±0.009	0.0649±0.0111	0.0388±0.0027
Our Method (MVKM)	**0.2088±0.0229**	**0.1603±0.0142**	**0.2150±0.0127**	**0.1654±0.0104**	**0.0613±0.0112**	**0.0362±0.0028**

Performance Prediction results on real datasets

Does Multiview help improve prediction performance?

Methods	Synthetic_NG		Synthetic_NG2		Synthetic_G	
	RMSE	MAE	RMSE	MAE	RMSE	MAE
MVKM-Base	0.2007±0.1069	0.1498±0.0809	0.3026±0.0697	0.2273±0.0356	0.2097±0.0485	0.1565±0.0348
MVKM-W /O-P	0.1714±0.0089	0.1306±0.0089	0.2817±0.0316	0.2213±0.0245	0.1796±0.0345	0.1357±0.0190
Our Method (MVKM)	**0.1388±0.0048**	**0.1049±0.0056**	**0.2221±0.0074**	**0.1739±0.0048**	**0.1532±0.0128**	**0.1171±0.0097**

Performance Prediction results on synthetic datasets

Methods	MORF_QD		MORF_QL		CANVAS_H	
	RMSE	MAE	RMSE	MAE	RMSE	MAE
MVKM-Base	0.2242±0.0328	0.1669±0.0207	0.2277±0.0119	0.1724±0.0081	0.0666±0.0159	0.0411±0.0040
MVKM-W /O-P	0.2385±0.0196	0.1771±0.0104	0.2450±0.0145	0.1814±0.009	0.0649±0.0111	0.0388±0.0027
Our Method (MVKM)	**0.2088±0.0229**	**0.1603±0.0142**	**0.2150±0.0127**	**0.1654±0.0104**	**0.0613±0.0112**	**0.0362±0.0028**

Performance Prediction results on real datasets

Does Multiview help improve prediction performance?

Yes!

Methods	Synthetic_NG		Synthetic_NG2		Synthetic_G	
	RMSE	MAE	RMSE	MAE	RMSE	MAE
MVKM-Base	0.2007±0.1069	0.1498±0.0809	0.3026±0.0697	0.2273±0.0356	0.2097±0.0485	0.1565±0.0348
MVKM-W /O-P	0.1714±0.0089	0.1306±0.0089	0.2817±0.0316	0.2213±0.0245	0.1796±0.0345	0.1357±0.0190
Our Method (MVKM)	**0.1388±0.0048**	**0.1049±0.0056**	**0.2221±0.0074**	**0.1739±0.0048**	**0.1532±0.0128**	**0.1171±0.0097**

Performance Prediction results on synthetic datasets

Methods	MORF_QD		MORF_QL		CANVAS_H	
	RMSE	MAE	RMSE	MAE	RMSE	MAE
MVKM-Base	0.2242±0.0328	0.1669±0.0207	0.2277±0.0119	0.1724±0.0081	0.0666±0.0159	0.0411±0.0040
MVKM-W /O-P	0.2385±0.0196	0.1771±0.0104	0.2450±0.0145	0.1814±0.009	0.0649±0.0111	0.0388±0.0027
Our Method (MVKM)	**0.2088±0.0229**	**0.1603±0.0142**	**0.2150±0.0127**	**0.1654±0.0104**	**0.0613±0.0112**	**0.0362±0.0028**

Performance Prediction results on real datasets

Is the Knowledge increase constraint essential?

Methods	Synthetic_NG		Synthetic_NG2		Synthetic_G	
	RMSE	MAE	RMSE	MAE	RMSE	MAE
MVKM-Base	0.2007±0.1069	0.1498±0.0809	0.3026±0.0697	0.2273±0.0356	0.2097±0.0485	0.1565±0.0348
MVKM-W /O-P	0.1714±0.0089	0.1306±0.0089	0.2817±0.0316	0.2213±0.0245	0.1796±0.0345	0.1357±0.0190
Our Method (MVKM)	**0.1388±0.0048**	**0.1049±0.0056**	**0.2221±0.0074**	**0.1739±0.0048**	**0.1532±0.0128**	**0.1171±0.0097**

Performance Prediction results on synthetic datasets

Methods	MORF_QD		MORF_QL		CANVAS_H	
	RMSE	MAE	RMSE	MAE	RMSE	MAE
MVKM-Base	0.2242±0.0328	0.1669±0.0207	0.2277±0.0119	0.1724±0.0081	0.0666±0.0159	0.0411±0.0040
MVKM-W /O-P	0.2385±0.0196	0.1771±0.0104	0.2450±0.0145	0.1814±0.009	0.0649±0.0111	0.0388±0.0027
Our Method (MVKM)	**0.2088±0.0229**	**0.1603±0.0142**	**0.2150±0.0127**	**0.1654±0.0104**	**0.0613±0.0112**	**0.0362±0.0028**

Performance Prediction results on real datasets

Is the Knowledge increase constraint essential?

UNIVERSITY AT ALBANY
State University of New York

Yes!

Methods	Synthetic_NG		Synthetic_NG2		Synthetic_G	
	RMSE	MAE	RMSE	MAE	RMSE	MAE
MVKM-Base	0.2007±0.1069	0.1498±0.0809	0.3026±0.0697	0.2273±0.0356	0.2097±0.0485	0.1565±0.0348
MVKM-W /O-P	0.1714±0.0089	0.1306±0.0089	0.2817±0.0316	0.2213±0.0245	0.1796±0.0345	0.1357±0.0190
Our Method (MVKM)	**0.1388±0.0048**	**0.1049±0.0056**	**0.2221±0.0074**	**0.1739±0.0048**	**0.1532±0.0128**	**0.1171±0.0097**

Performance Prediction results on synthetic datasets

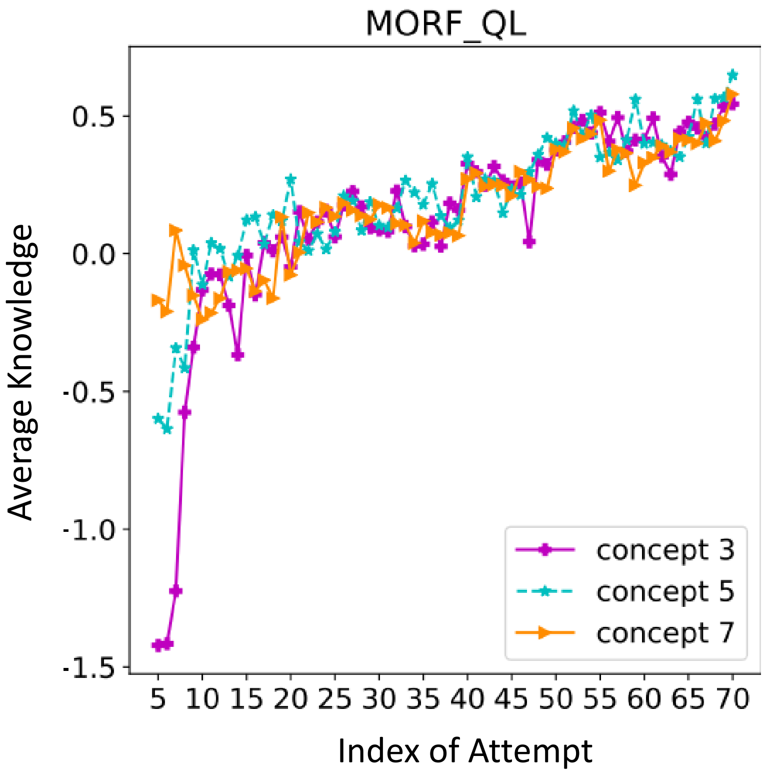
Methods	MORF_QD		MORF_QL		CANVAS_H	
	RMSE	MAE	RMSE	MAE	RMSE	MAE
MVKM-Base	0.2242±0.0328	0.1669±0.0207	0.2277±0.0119	0.1724±0.0081	0.0666±0.0159	0.0411±0.0040
MVKM-W /O-P	0.2385±0.0196	0.1771±0.0104	0.2450±0.0145	0.1814±0.009	0.0649±0.0111	0.0388±0.0027
Our Method (MVKM)	**0.2088±0.0229**	**0.1603±0.0142**	**0.2150±0.0127**	**0.1654±0.0104**	**0.0613±0.0112**	**0.0362±0.0028**

Performance Prediction results on real datasets

Student Knowledge Modeling

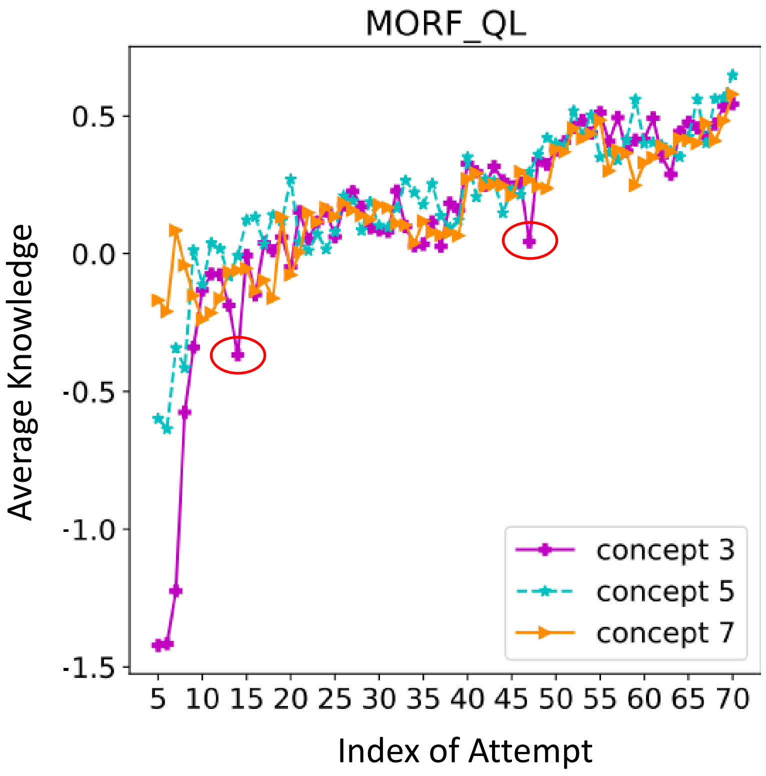
- Students Knowledge gain
- Knowledge increase constraint

Students' knowledge increase, but not strict



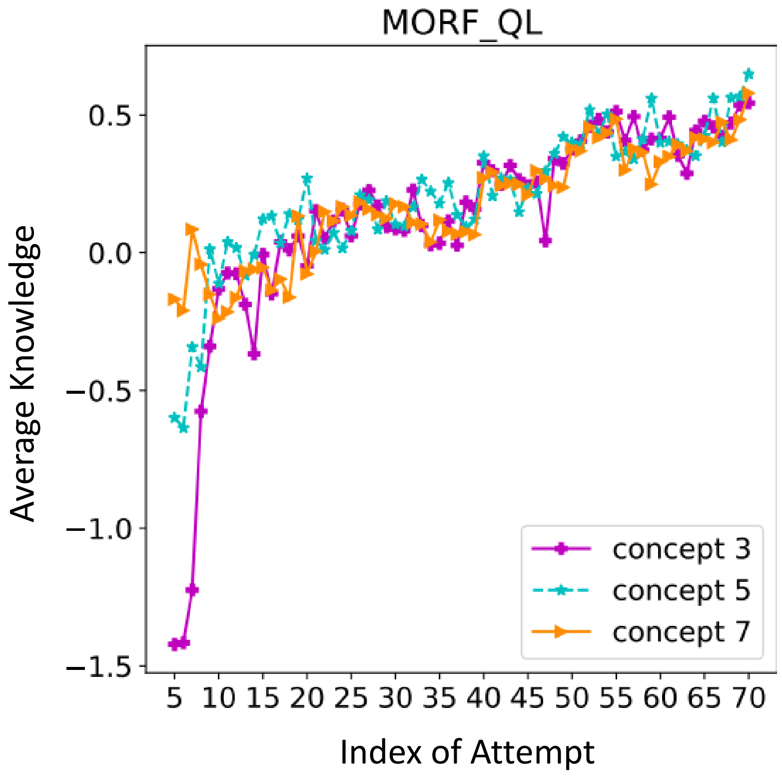
Knowledge gain

Students’ knowledge increase, but not strict

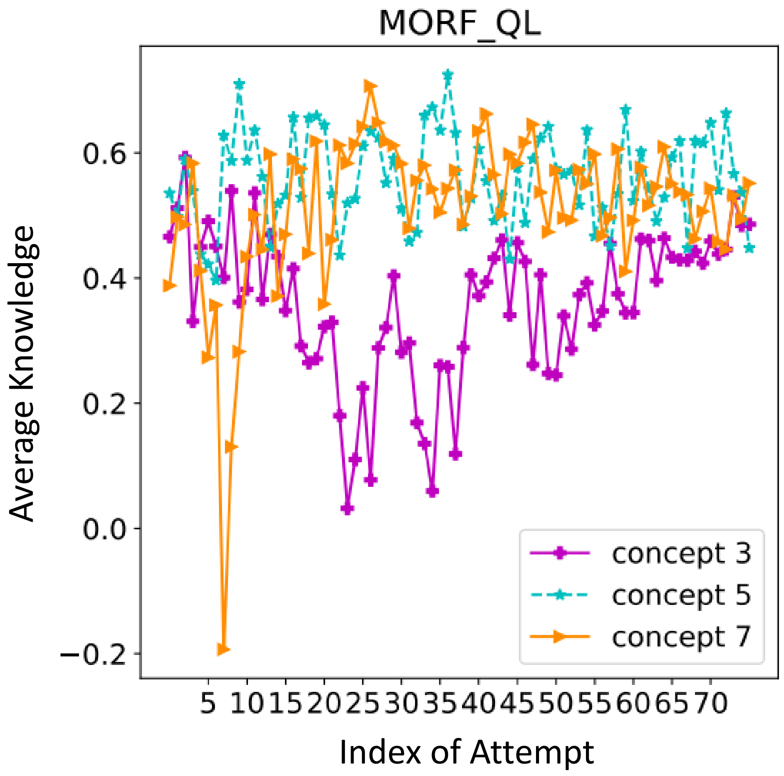


Knowledge gain

What if we remove the knowledge increase constraint?



MVKM



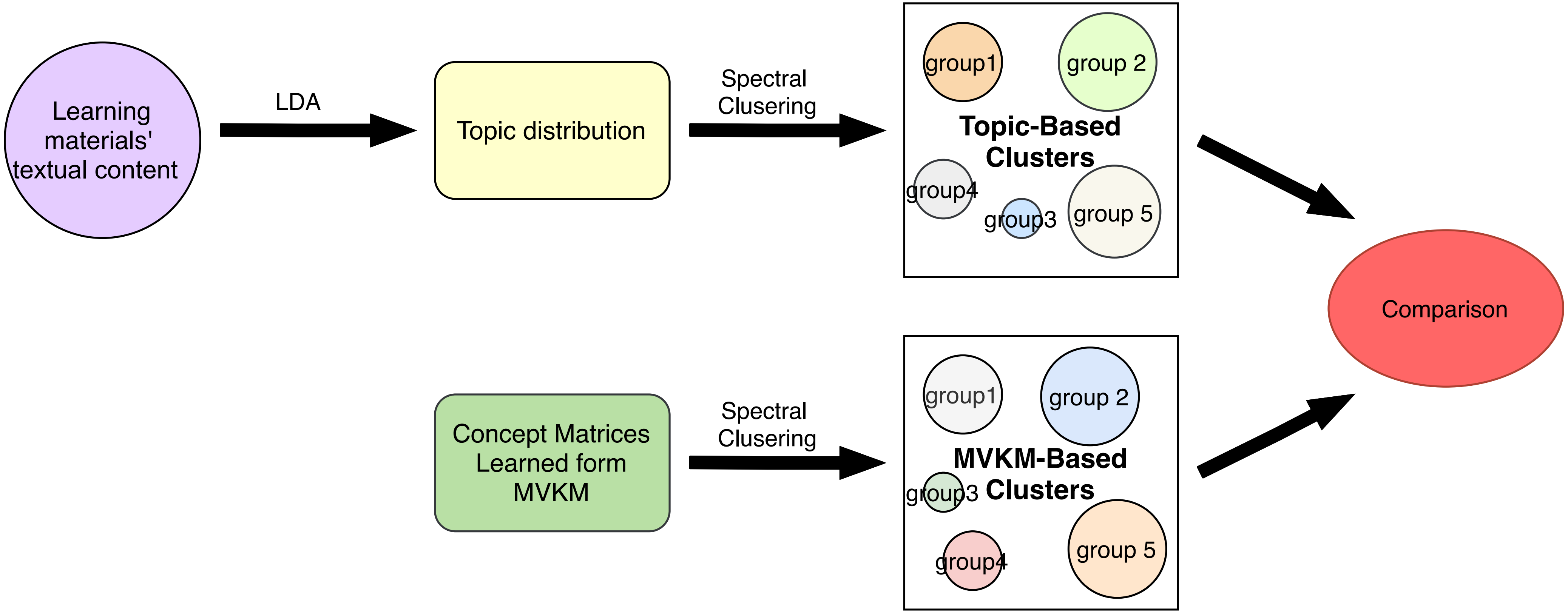
MVKM-W/O-P

Learning Resource Modeling

UNIVERSITY AT ALBANY
State University of New York

- Within-Type Concept Evaluation
- Between-Type Concept Evaluation

Learning Resource Modeling



Within-Type Concept Evaluation

UNIVERSITY AT ALBANY
State University of New York

Both structural similarities and content similarities exist

Cluster 1
- W1 V6: Case Study - San Pedro

Cluster 2
- W1 V2: Regressors
- W3 V1: Ground Truth for Behavior Detection
- W3 V2: Data Synchronization and Grain Sizes
- W3 V3: Feature Engineering
- W3 V4: Automated Feature Generation
- W3 V5: Knowledge Engineering

Cluster 3
- W2 V1: Detector Confidence
- W4 V4: Item Response Theory
- W4 V5: Advanced BKT
- W5 V1: Correlation Mining
- W5 V2: Casual Mining
- W5 V3: Association Rule Mining
- W5 V4: Sequential Pattern Mining
- W5 V5: Network Analysis
- W6 V1: Learning Curves
- W6 V3: Scatter Plots
- W6 V4: State Space Diagrams
- W6 V5: Other Awesome EDM Visualizations
- W7 V1: Clustering
- W7 V2: Validation and Selection of K
- W8 V3: Text Mining

Cluster 4
- W1 V3: Classifiers Part 1

Cluster 5
- W1 V5: Classifiers Part 3

Cluster 6
- W2 V2: Diagnostic Metrics, part 1
- W2 V3: Diagnostic Metrics, part 2

Cluster 7
- Week 1 Introduction
- W1 V1: Big Data in Education

Cluster 8
- W1 V4: Classifiers Part 2 - RapidMiner
- W2 V6: Types of validity
- W4 V1: Knowledge Inference
- W4 V2: Bayesian Knowledge Tracing
- W4 V3: Performance Factors Analysis
- W7 V3: Advanced Clustering Algorithms
- W7 V4: Clustering Examples
- W7 V5: Factor Analysis
- W8 V1: Discovery with Models
- W8 V2: Discovery with Models - Case Study
- W8 V4: Hidden Markov Models
- W8 V5: Conclusions and Further Directions

Clusters that were discovered by using MVKM

Cluster 1
- Week 1 Introduction
- W1 V1: Big Data in Education
- W1 V2: Regressors
- W1 V4: Classifiers Part 2 - RapidMiner
- W1 V6: Case Study - San Pedro
- W2 V1: Detector Confidence
- W2 V6: Types of validity
- W3 V2: Data Synchronization and Grain Sizes
- W5 V5: Network Analysis
- W6 V1: Learning Curves
- W6 V5: Other Awesome EDM Visualizations
- W8 V1: Discovery with Models
- W8 V5: Conclusions and Further Directions

Cluster 2
- W4 V2: Bayesian Knowledge Tracing
- W4 V3: Performance Factors Analysis
- W4 V4: Item Response Theory
- W7 V5: Factor Analysis
- W8 V4: Hidden Markov Models

Cluster 3
- W2 V2: Diagnostic Metrics, part 1
- W3 V5: Knowledge Engineering
- W4 V1: Knowledge Inference

Cluster 4
- W1 V3: Classifiers Part 1
- W3 V3: Feature Engineering

Cluster 5
- W1 V5: Classifiers Part 3
- W3 V4: Automated Feature Generation
- W5 V2: Casual Mining

Cluster 6
- W2 V3: Diagnostic Metrics, part 2
- W5 V1: Correlation Mining
- W6 V4: State Space Diagrams

Cluster 7
- W4 V5: Advanced BKT
- W6 V3: Scatter Plots
- W7 V1: Clustering
- W7 V2: Validation and Selection of K
- W7 V3: Advanced Clustering Algorithms
- W7 V4: Clustering Examples

Cluster 8
- W3 V1: Ground Truth for Behavior Detection
- W5 V3: Association Rule Mining
- W5 V4: Sequential Pattern Mining
- W8 V2: Discovery with Models - Case Study
- W8 V3: Text Mining

Clusters discovered by using LDA topics

Within-Type Concept Evaluation

Both structural similarities and content similarities exist

Clusters that were discovered by using MVKM

1
- W1 V6: Case Study - San Pedro

2
- W1 V2: Regressors
- W3 V1: Ground Truth for Behavior Detection
- W3 V2: Data Synchronization and Grain Sizes
- W3 V3: Feature Engineering
- W3 V4: Automated Feature Generation
- W3 V5: Knowledge Engineering

3
- W2 V1: Detector Confidence
- W4 V4: Item Response Theory
- W4 V5: Advanced BKT
- W5 V1: Correlation Mining
- W5 V2: Casual Mining
- W5 V3: Association Rule Mining
- W5 V4: Sequential Pattern Mining
- W5 V5: Network Analysis
- W6 V1: Learning Curves
- W6 V3: Scatter Plots
- W6 V4: State Space Diagrams
- W6 V5: Other Awesome EDM Visualizations
- W7 V1: Clustering
- W7 V2: Validation and Selection of K
- W8 V3: Text Mining

4
- W1 V3: Classifiers Part 1

5
- W1 V5: Classifiers Part 3

6
- W2 V2: Diagnostic Metrics, part 1
- W2 V3: Diagnostic Metrics, part 2

7
- Week 1 Introduction
- W1 V1: Big Data in Education

8
- W1 V4: Classifiers Part 2 - RapidMiner
- W2 V6: Types of validity
- W4 V1: Knowledge Inference
- W4 V2: Bayesian Knowledge Tracing
- W4 V3: Performance Factors Analysis
- W7 V3: Advanced Clustering Algorithms
- W7 V4: Clustering Examples
- W7 V5: Factor Analysis
- W8 V1: Discovery with Models
- W8 V2: Discovery with Models - Case Study
- W8 V4: Hidden Markov Models
- W8 V5: Conclusions and Further Directions

Clusters discovered by using LDA topics

1
- Week 1 Introduction
- W1 V1: Big Data in Education
- W1 V2: Regressors
- W1 V4: Classifiers Part 2 - RapidMiner
- W1 V6: Case Study - San Pedro
- W2 V1: Detector Confidence
- W2 V6: Types of validity
- W3 V2: Data Synchronization and Grain Sizes
- W5 V5: Network Analysis
- W6 V1: Learning Curves
- W6 V5: Other Awesome EDM Visualizations
- W8 V1: Discovery with Models
- W8 V5: Conclusions and Further Directions

2
- W4 V2: Bayesian Knowledge Tracing
- W4 V3: Performance Factors Analysis
- W4 V4: Item Response Theory
- W7 V5: Factor Analysis
- W8 V4: Hidden Markov Models

3
- W2 V2: Diagnostic Metrics, part 1
- W3 V5: Knowledge Engineering
- W4 V1: Knowledge Inference

4
- W1 V3: Classifiers Part 1
- W3 V3: Feature Engineering

5
- W1 V5: Classifiers Part 3
- W3 V4: Automated Feature Generation
- W5 V2: Casual Mining

6
- W2 V3: Diagnostic Metrics, part 2
- W5 V1: Correlation Mining
- W6 V4: State Space Diagrams

7
- W4 V5: Advanced BKT
- W6 V3: Scatter Plots
- W7 V1: Clustering
- W7 V2: Validation and Selection of K
- W7 V3: Advanced Clustering Algorithms
- W7 V4: Clustering Examples

8
- W3 V1: Ground Truth for Behavior Detection
- W5 V3: Association Rule Mining
- W5 V4: Sequential Pattern Mining
- W8 V2: Discovery with Models - Case Study
- W8 V3: Text Mining

Within-Type Concept Evaluation

UNIVERSITY AT ALBANY
State University of New York

Both structural similarities and content similarities exist

Clusters that were discovered by using MVKM

1
- W1 V6: Case Study - San Pedro

2
- W1 V2: Regressors
- W3 V1: Ground Truth for Behavior Detection
- W3 V2: Data Synchronization and Grain Sizes
- W3 V3: Feature Engineering
- W3 V4: Automated Feature Generation
- W3 V5: Knowledge Engineering

3
- W2 V1: Detector Confidence
- W4 V4: Item Response Theory
- W4 V5: Advanced BKT
- W5 V1: Correlation Mining
- W5 V2: Casual Mining
- W5 V3: Association Rule Mining
- W5 V4: Sequential Pattern Mining
- W5 V5: Network Analysis
- W6 V1: Learning Curves
- W6 V3: Scatter Plots
- W6 V4: State Space Diagrams
- W6 V5: Other Awesome EDM Visualizations
- W7 V1: Clustering
- W7 V2: Validation and Selection of K
- W8 V3: Text Mining

4
- W1 V3: Classifiers Part 1

5
- W1 V5: Classifiers Part 3

6
- W2 V2: Diagnostic Metrics, part 1
- W2 V3: Diagnostic Metrics, part 2

7
- Week 1 Introduction
- W1 V1: Big Data in Education

8
- W1 V4: Classifiers Part 2 - RapidMiner
- W2 V6: Types of validity
- W4 V1: Knowledge Inference
- W4 V2: Bayesian Knowledge Tracing
- W4 V3: Performance Factors Analysis
- W7 V3: Advanced Clustering Algorithms
- W7 V4: Clustering Examples
- W7 V5: Factor Analysis
- W8 V1: Discovery with Models
- W8 V2: Discovery with Models - Case Study
- W8 V4: Hidden Markov Models
- W8 V5: Conclusions and Further Directions

Clusters discovered by using LDA topics

1
- Week 1 Introduction
- W1 V1: Big Data in Education
- W1 V2: Regressors
- W1 V4: Classifiers Part 2 - RapidMiner
- W1 V6: Case Study - San Pedro
- W2 V1: Detector Confidence
- W2 V6: Types of validity
- W3 V2: Data Synchronization and Grain Sizes
- W5 V5: Network Analysis
- W6 V1: Learning Curves
- W6 V5: Other Awesome EDM Visualizations
- W8 V1: Discovery with Models
- W8 V5: Conclusions and Further Directions

2
- W4 V2: Bayesian Knowledge Tracing
- W4 V3: Performance Factors Analysis
- W4 V4: Item Response Theory
- W7 V5: Factor Analysis
- W8 V4: Hidden Markov Models

3
- W2 V2: Diagnostic Metrics, part 1
- W3 V5: Knowledge Engineering
- W4 V1: Knowledge Inference

4
- W1 V3: Classifiers Part 1
- W3 V3: Feature Engineering

5
- W1 V5: Classifiers Part 3
- W3 V4: Automated Feature Generation
- W5 V2: Casual Mining

6
- W2 V3: Diagnostic Metrics, part 2
- W5 V1: Correlation Mining
- W6 V4: State Space Diagrams

7
- W4 V5: Advanced BKT
- W6 V3: Scatter Plots
- W7 V1: Clustering
- W7 V2: Validation and Selection of K
- W7 V3: Advanced Clustering Algorithms
- W7 V4: Clustering Examples

8
- W3 V1: Ground Truth for Behavior Detection
- W5 V3: Association Rule Mining
- W5 V4: Sequential Pattern Mining
- W8 V2: Discovery with Models - Case Study
- W8 V3: Text Mining

Within-Type Concept Evaluation

MVKM mostly represent the course structure similarity

Cluster 1
- W1 V6: Case Study - San Pedro

Cluster 2
- W1 V2: Regressors
- W3 V1: Ground Truth for Behavior Detection
- W3 V2: Data Synchronization and Grain Sizes
- W3 V3: Feature Engineering
- W3 V4: Automated Feature Generation
- W3 V5: Knowledge Engineering

Cluster 3
- W2 V1: Detector Confidence
- W4 V4: Item Response Theory
- W4 V5: Advanced BKT
- W5 V1: Correlation Mining
- W5 V2: Casual Mining
- W5 V3: Association Rule Mining
- W5 V4: Sequential Pattern Mining
- W5 V5: Network Analysis
- W6 V1: Learning Curves
- W6 V3: Scatter Plots
- W6 V4: State Space Diagrams
- W6 V5: Other Awesome EDM Visualizations
- W7 V1: Clustering
- W7 V2: Validation and Selection of K
- W8 V3: Text Mining

Cluster 4
- W1 V3: Classifiers Part 1

Cluster 5
- W1 V5: Classifiers Part 3

Cluster 6
- W2 V2: Diagnostic Metrics, part 1
- W2 V3: Diagnostic Metrics, part 2

Cluster 7
- Week 1 Introduction
- W1 V1: Big Data in Education

Cluster 8
- W1 V4: Classifiers Part 2 - RapidMiner
- W2 V6: Types of validity
- W4 V1: Knowledge Inference
- W4 V2: Bayesian Knowledge Tracing
- W4 V3: Performance Factors Analysis
- W7 V3: Advanced Clustering Algorithms
- W7 V4: Clustering Examples
- W7 V5: Factor Analysis
- W8 V1: Discovery with Models
- W8 V2: Discovery with Models - Case Study
- W8 V4: Hidden Markov Models
- W8 V5: Conclusions and Further Directions

Clusters that were discovered by using MVKM

Cluster 1
- Week 1 Introduction
- W1 V1: Big Data in Education
- W1 V2: Regressors
- W1 V4: Classifiers Part 2 - RapidMiner
- W1 V6: Case Study - San Pedro
- W2 V1: Detector Confidence
- W2 V6: Types of validity
- W3 V2: Data Synchronization and Grain Sizes
- W5 V5: Network Analysis
- W6 V1: Learning Curves
- W6 V5: Other Awesome EDM Visualizations
- W8 V1: Discovery with Models
- W8 V5: Conclusions and Further Directions

Cluster 2
- W4 V2: Bayesian Knowledge Tracing
- W4 V3: Performance Factors Analysis
- W4 V4: Item Response Theory
- W7 V5: Factor Analysis
- W8 V4: Hidden Markov Models

Cluster 3
- W2 V2: Diagnostic Metrics, part 1
- W3 V5: Knowledge Engineering
- W4 V1: Knowledge Inference

Cluster 4
- W1 V3: Classifiers Part 1
- W3 V3: Feature Engineering

Cluster 5
- W1 V5: Classifiers Part 3
- W3 V4: Automated Feature Generation
- W5 V2: Casual Mining

Cluster 6
- W2 V3: Diagnostic Metrics, part 2
- W5 V1: Correlation Mining
- W6 V4: State Space Diagrams

Cluster 7
- W4 V5: Advanced BKT
- W6 V3: Scatter Plots
- W7 V1: Clustering
- W7 V2: Validation and Selection of K
- W7 V3: Advanced Clustering Algorithms
- W7 V4: Clustering Examples

Cluster 8
- W3 V1: Ground Truth for Behavior Detection
- W5 V3: Association Rule Mining
- W5 V4: Sequential Pattern Mining
- W8 V2: Discovery with Models - Case Study
- W8 V3: Text Mining

Clusters discovered by using LDA topics

Within-Type Concept Evaluation

UNIVERSITY AT ALBANY
State University of New York

MVKM mostly represent the course structure similarity

Clusters that were discovered by using MVKM

1:
- W1 V6: Case Study - San Pedro

2:
- W1 V2: Regressors
- W3 V1: Ground Truth for Behavior Detection
- W3 V2: Data Synchronization and Grain Sizes
- W3 V3: Feature Engineering
- W3 V4: Automated Feature Generation
- W3 V5: Knowledge Engineering

3:
- W2 V1: Detector Confidence
- W4 V4: Item Response Theory
- W4 V5: Advanced BKT
- W5 V1: Correlation Mining
- W5 V2: Casual Mining
- W5 V3: Association Rule Mining
- W5 V4: Sequential Pattern Mining
- W5 V5: Network Analysis
- W6 V1: Learning Curves
- W6 V3: Scatter Plots
- W6 V4: State Space Diagrams
- W6 V5: Other Awesome EDM Visualizations
- W7 V1: Clustering
- W7 V2: Validation and Selection of K
- W8 V3: Text Mining

4:
- W1 V3: Classifiers Part 1

5:
- W1 V5: Classifiers Part 3

6:
- W2 V2: Diagnostic Metrics, part 1
- W2 V3: Diagnostic Metrics, part 2

7:
- Week 1 Introduction
- W1 V1: Big Data in Education

8:
- W1 V4: Classifiers Part 2 - RapidMiner
- W2 V6: Types of validity
- W4 V1: Knowledge Inference
- W4 V2: Bayesian Knowledge Tracing
- W4 V3: Performance Factors Analysis
- W7 V3: Advanced Clustering Algorithms
- W7 V4: Clustering Examples
- W7 V5: Factor Analysis
- W8 V1: Discovery with Models
- W8 V2: Discovery with Models - Case Study
- W8 V4: Hidden Markov Models
- W8 V5: Conclusions and Further Directions

Clusters discovered by using LDA topics

1:
- Week 1 Introduction
- W1 V1: Big Data in Education
- W1 V2: Regressors
- W1 V4: Classifiers Part 2 - RapidMiner
- W1 V6: Case Study - San Pedro
- W2 V1: Detector Confidence
- W2 V6: Types of validity
- W3 V2: Data Synchronization and Grain Sizes
- W5 V5: Network Analysis
- W6 V1: Learning Curves
- W6 V5: Other Awesome EDM Visualizations
- W8 V1: Discovery with Models
- W8 V5: Conclusions and Further Directions

2:
- W4 V2: Bayesian Knowledge Tracing
- W4 V3: Performance Factors Analysis
- W4 V4: Item Response Theory
- W7 V5: Factor Analysis
- W8 V4: Hidden Markov Models

3:
- W2 V2: Diagnostic Metrics, part 1
- W3 V5: Knowledge Engineering
- W4 V1: Knowledge Inference

4:
- W1 V3: Classifiers Part 1
- W3 V3: Feature Engineering

5:
- W1 V5: Classifiers Part 3
- W3 V4: Automated Feature Generation
- W5 V2: Casual Mining

6:
- W2 V3: Diagnostic Metrics, part 2
- W5 V1: Correlation Mining
- W6 V4: State Space Diagrams

7:
- W4 V5: Advanced BKT
- W6 V3: Scatter Plots
- W7 V1: Clustering
- W7 V2: Validation and Selection of K
- W7 V3: Advanced Clustering Algorithms
- W7 V4: Clustering Examples

8:
- W3 V1: Ground Truth for Behavior Detection
- W5 V3: Association Rule Mining
- W5 V4: Sequential Pattern Mining
- W8 V2: Discovery with Models - Case Study
- W8 V3: Text Mining

Between-Type Concept Evaluation

UNIVERSITY AT ALBANY
State University of New York

Both structural similarities and content similarities exist

Cluster 1
W2 V1: Detector Confidence
W2 V2: Diagnostic Metrics, part 1
W2 V3: Diagnostic Metrics, part 2
W4 V5: Advanced BKT
Assignment 4
W5 V1: Correlation Mining
W5 V2: Casual Mining
W5 V3: Association Rule Mining
W5 V4: Sequential Pattern Mining
W5 V5: Network Analysis
Assignment 5
W6 V1: Learning Curves
W6 V3: Scatter Plots
W6 V4: State Space Diagrams
W6 V5: Other Awesome EDM Visualizations
Assignment 6
W7 V2: Validation and Selection of K

Cluster 2
Week 1 Introduction
W1 V1: Big Data in Education
W2 V6: Types of validity
W3 V5: Knowledge Engineering
Assignment 3
W4 V1: Knowledge Inference
W4 V2: Bayesian Knowledge Tracing
W4 V3: Performance Factors Analysis
W4 V4: Item Response Theory

Cluster 3
W1 V6: Case Study - San Pedro

Cluster 4
W1 V4: Classifiers Part 2 - RapidMiner

Cluster 5
Assignment 1

Cluster 6
W1 V3: Classifiers Part 1

Cluster 7
W1 V2: Regressors
Assignment 2
W3 V1: Ground Truth for Behavior Detection
W3 V2: Data Synchronization and Grain Sizes
W3 V3: Feature Engineering
W3 V4: Automated Feature Generation

Cluster 8
W1 V5: Classifiers Part 3
W7 V1: Clustering
W7 V3: Advanced Clustering Algorithms
W7 V4: Clustering Examples
W7 V5: Factor Analysis
Assignment 7
W8 V1: Discovery with Models
W8 V2: Discovery with Models - Case Study
W8 V3: Text Mining
W8 V4: Hidden Markov Models
W8 V5: Conclusions and Further Directions
Assignment 8

Clusters that were discovered by using MVKM

Cluster 1
W1 V2: Regressors
W1 V4: Classifiers Part 2 - RapidMiner
W1 V5: Classifiers Part 3
Assignment 2
W5 V5: Network Analysis
W6 V1: Learning Curves
W6 V3: Scatter Plots
W6 V5: Other Awesome EDM Visualizations
W7 V1: Clustering
W7 V2: Validation and Selection of K
W7 V3: Advanced Clustering Algorithms
W7 V4: Clustering Examples
Assignment 7
W8 V2: Discovery with Models - Case Study
Assignment 8

Cluster 2
Week 1 Introduction
W3 V2: Data Synchronization and Grain Sizes
W3 V3: Feature Engineering
Assignment 3
Assignment 4
W8 V3: Text Mining

Cluster 3
W2 V1: Detector Confidence
W2 V3: Diagnostic Metrics, part 2
W5 V3: Association Rule Mining
W5 V4: Sequential Pattern Mining

Cluster 4
W1: V3: Classifiers Part 1
Assignment 1

Cluster 5
W2 V2: Diagnostic Metrics, part 1
W2 V6: Types of validity
W3 V1: Ground Truth for Behavior Detection
W3 V5: Knowledge Engineering
W5 V2: Casual Mining

Cluster 6
W1 V1: Big Data in Education
W1 V6: Case Study - San Pedro
W3 V4: Automated Feature Generation
W5 V1: Correlation Mining
Assignment 5
W8 V5: Conclusions and Further Directions

Cluster 7
W4 V1: Knowledge Inference
W4 V2: Bayesian Knowledge Tracing
W4 V3: Performance Factors Analysis
W4 V4: Item Response Theory
W4 V5: Advanced BKT
W6 V4: State Space Diagrams
W8 V1: Discovery with Models
W8 V4: Hidden Markov Models

Cluster 8
Assignment 6
W7 V5: Factor Analysis

Clusters discovered by using LDA topics

Between-Type Concept Evaluation

UNIVERSITY AT ALBANY
State University of New York

Both structural similarities and content similarities exist

Cluster 1
- W2 V1: Detector Confidence
- W2 V2: Diagnostic Metrics, part 1
- W2 V3: Diagnostic Metrics, part 2
- W4 V5: Advanced BKT
- **Assignment 4**
- W5 V1: Correlation Mining
- W5 V2: Casual Mining
- W5 V3: Association Rule Mining
- W5 V4: Sequential Pattern Mining
- W5 V5: Network Analysis
- **Assignment 5**
- W6 V1: Learning Curves
- W6 V3: Scatter Plots
- W6 V4: State Space Diagrams
- W6 V5: Other Awesome EDM Visualizations
- **Assignment 6**
- W7 V2: Validation and Selection of K

Cluster 2
- Week 1 Introduction
- W1 V1: Big Data in Education
- W2 V6: Types of validity
- W3 V5: Knowledge Engineering
- **Assignment 3**
- W4 V1: Knowledge Inference
- W4 V2: Bayesian Knowledge Tracing
- W4 V3: Performance Factors Analysis
- W4 V4: Item Response Theory

Cluster 3
- W1 V6: Case Study - San Pedro

Cluster 4
- W1 V4: Classifiers Part 2 - RapidMiner

Cluster 5
- **Assignment 1**

Cluster 6
- W1 V3: Classifiers Part 1

Cluster 7
- W1 V2: Regressors
- **Assignment 2**
- W3 V1: Ground Truth for Behavior Detection
- W3 V2: Data Synchronization and Grain Sizes
- W3 V3: Feature Engineering
- W3 V4: Automated Feature Generation

Cluster 8
- W1 V5: Classifiers Part 3
- W7 V1: Clustering
- W7 V3: Advanced Clustering Algorithms
- W7 V4: Clustering Examples
- W7 V5: Factor Analysis
- **Assignment 7**
- W8 V1: Discovery with Models
- W8 V2: Discovery with Models - Case Study
- W8 V3: Text Mining
- W8 V4: Hidden Markov Models
- W8 V5: Conclusions and Further Directions
- **Assignment 8**

Clusters that were discovered by using MVKM

Cluster 1
- W1 V2: Regressors
- W1 V4: Classifiers Part 2 - RapidMiner
- W1 V5: Classifiers Part 3
- **Assignment 2**
- W5 V5: Network Analysis
- W6 V1: Learning Curves
- W6 V3: Scatter Plots
- W6 V5: Other Awesome EDM Visualizations
- W7 V1: Clustering
- W7 V2: Validation and Selection of K
- W7 V3: Advanced Clustering Algorithms
- W7 V4: Clustering Examples
- **Assignment 7**
- W8 V2: Discovery with Models - Case Study
- **Assignment 8**

Cluster 2
- Week 1 Introduction
- W3 V2: Data Synchronization and Grain Sizes
- W3 V3: Feature Engineering
- **Assignment 3**
- **Assignment 4**
- W8 V3: Text Mining

Cluster 3
- W2 V1: Detector Confidence
- W2 V3: Diagnostic Metrics, part 2
- W5 V3: Association Rule Mining
- W5 V4: Sequential Pattern Mining

Cluster 4
- W1: V3: Classifiers Part 1
- **Assignment 1**

Cluster 5
- W2 V2: Diagnostic Metrics, part 1
- W2 V6: Types of validity
- W3 V1: Ground Truth for Behavior Detection
- W3 V5: Knowledge Engineering
- W5 V2: Casual Mining

Cluster 6
- W1 V1: Big Data in Education
- W1 V6: Case Study - San Pedro
- W3 V4: Automated Feature Generation
- W5 V1: Correlation Mining
- **Assignment 5**
- W8 V5: Conclusions and Further Directions

Cluster 7
- W4 V1: Knowledge Inference
- W4 V2: Bayesian Knowledge Tracing
- W4 V3: Performance Factors Analysis
- W4 V4: Item Response Theory
- W4 V5: Advanced BKT
- W6 V4: State Space Diagrams
- W8 V1: Discovery with Models
- W8 V4: Hidden Markov Models

Cluster 8
- **Assignment 6**
- W7 V5: Factor Analysis

Clusters discovered by using LDA topics

Between-Type Concept Evaluation

UNIVERSITY AT ALBANY
State University of New York

Both structural similarities and content similarities exist

Clusters that were discovered by using MVKM

1
- W2 V1: Detector Confidence
- W2 V2: Diagnostic Metrics, part 1
- W2 V3: Diagnostic Metrics, part 2
- W4 V5: Advanced BKT
- **Assignment 4**
- W5 V1: Correlation Mining
- W5 V2: Casual Mining
- W5 V3: Association Rule Mining
- W5 V4: Sequential Pattern Mining
- W5 V5: Network Analysis
- **Assignment 5**
- W6 V1: Learning Curves
- W6 V3: Scatter Plots
- W6 V4: State Space Diagrams
- W6 V5: Other Awesome EDM Visualizations
- **Assignment 6**
- W7 V2: Validation and Selection of K

2
- Week 1 Introduction
- W1 V1: Big Data in Education
- W2 V6: Types of validity
- W3 V5: Knowledge Engineering
- **Assignment 3**
- W4 V1: Knowledge Inference
- W4 V2: Bayesian Knowledge Tracing
- W4 V3: Performance Factors Analysis
- W4 V4: Item Response Theory

3
- W1 V6: Case Study - San Pedro

4
- W1 V4: Classifiers Part 2 - RapidMiner

5
- **Assignment 1**

6
- W1 V3: Classifiers Part 1

7
- W1 V2: Regressors
- **Assignment 2**
- W3 V1: Ground Truth for Behavior Detection
- W3 V2: Data Synchronization and Grain Sizes
- W3 V3: Feature Engineering
- W3 V4: Automated Feature Generation

8
- W1 V5: Classifiers Part 3
- W7 V1: Clustering
- W7 V3: Advanced Clustering Algorithms
- W7 V4: Clustering Examples
- W7 V5: Factor Analysis
- **Assignment 7**
- W8 V1: Discovery with Models
- W8 V2: Discovery with Models - Case Study
- W8 V3: Text Mining
- W8 V4: Hidden Markov Models
- W8 V5: Conclusions and Further Directions
- **Assignment 8**

Clusters discovered by using LDA topics

1
- W1 V2: Regressors
- W1 V4: Classifiers Part 2 - RapidMiner
- W1 V5: Classifiers Part 3
- **Assignment 2**
- W5 V5: Network Analysis
- W6 V1: Learning Curves
- W6 V3: Scatter Plots
- W6 V5: Other Awesome EDM Visualizations
- W7 V1: Clustering
- W7 V2: Validation and Selection of K
- W7 V3: Advanced Clustering Algorithms
- W7 V4: Clustering Examples
- **Assignment 7**
- W8 V2: Discovery with Models - Case Study
- **Assignment 8**

2
- Week 1 Introduction
- W3 V2: Data Synchronization and Grain Sizes
- W3 V3: Feature Engineering
- **Assignment 3**
- **Assignment 4**
- W8 V3: Text Mining

3
- W2 V1: Detector Confidence
- W2 V3: Diagnostic Metrics, part 2
- W5 V3: Association Rule Mining
- W5 V4: Sequential Pattern Mining

4
- W1: V3: Classifiers Part 1
- **Assignment 1**

5
- W2 V2: Diagnostic Metrics, part 1
- W2 V6: Types of validity
- W3 V1: Ground Truth for Behavior Detection
- W3 V5: Knowledge Engineering
- W5 V2: Casual Mining

6
- W1 V1: Big Data in Education
- W1 V6: Case Study - San Pedro
- W3 V4: Automated Feature Generation
- W5 V1: Correlation Mining
- **Assignment 5**
- W8 V5: Conclusions and Further Directions

7
- W4 V1: Knowledge Inference
- W4 V2: Bayesian Knowledge Tracing
- W4 V3: Performance Factors Analysis
- W4 V4: Item Response Theory
- W4 V5: Advanced BKT
- W6 V4: State Space Diagrams
- W8 V1: Discovery with Models
- W8 V4: Hidden Markov Models

8
- **Assignment 6**
- W7 V5: Factor Analysis

Between-Type Concept Evaluation

UNIVERSITY AT ALBANY
State University of New York

Assignments are grouped with the upcoming lecture

Clusters that were discovered by using MVKM

1
W2 V1: Detector Confidence
W2 V2: Diagnostic Metrics, part 1
W2 V3: Diagnostic Metrics, part 2
W4 V5: Advanced BKT
Assignment 4
W5 V1: Correlation Mining
W5 V2: Casual Mining
W5 V3: Association Rule Mining
W5 V4: Sequential Pattern Mining
W5 V5: Network Analysis
Assignment 5
W6 V1: Learning Curves
W6 V3: Scatter Plots
W6 V4: State Space Diagrams
W6 V5: Other Awesome EDM Visualizations
Assignment 6
W7 V2: Validation and Selection of K

2
Week 1 Introduction
W1 V1: Big Data in Education
W2 V6: Types of validity
W3 V5: Knowledge Engineering
Assignment 3
W4 V1: Knowledge Inference
W4 V2: Bayesian Knowledge Tracing
W4 V3: Performance Factors Analysis
W4 V4: Item Response Theory

3
W1 V6: Case Study - San Pedro

4
W1 V4: Classifiers Part 2 - RapidMiner

5
Assignment 1

6
W1 V3: Classifiers Part 1

7
W1 V2: Regressors
Assignment 2
W3 V1: Ground Truth for Behavior Detection
W3 V2: Data Synchronization and Grain Sizes
W3 V3: Feature Engineering
W3 V4: Automated Feature Generation

8
W1 V5: Classifiers Part 3
W7 V1: Clustering
W7 V3: Advanced Clustering Algorithms
W7 V4: Clustering Examples
W7 V5: Factor Analysis
Assignment 7
W8 V1: Discovery with Models
W8 V2: Discovery with Models - Case Study
W8 V3: Text Mining
W8 V4: Hidden Markov Models
W8 V5: Conclusions and Further Directions
Assignment 8

Clusters discovered by using LDA topics

1
W1 V2: Regressors
W1 V4: Classifiers Part 2 - RapidMiner
W1 V5: Classifiers Part 3
Assignment 2
W5 V5: Network Analysis
W6 V1: Learning Curves
W6 V3: Scatter Plots
W6 V5: Other Awesome EDM Visualizations
W7 V1: Clustering
W7 V2: Validation and Selection of K
W7 V3: Advanced Clustering Algorithms
W7 V4: Clustering Examples
Assignment 7
W8 V2: Discovery with Models - Case Study
Assignment 8

2
Week 1 Introduction
W3 V2: Data Synchronization and Grain Sizes
W3 V3: Feature Engineering
Assignment 3
Assignment 4
W8 V3: Text Mining

3
W2 V1: Detector Confidence
W2 V3: Diagnostic Metrics, part 2
W5 V3: Association Rule Mining
W5 V4: Sequential Pattern Mining

4
W1: V3: Classifiers Part 1
Assignment 1

5
W2 V2: Diagnostic Metrics, part 1
W2 V6: Types of validity
W3 V1: Ground Truth for Behavior Detection
W3 V5: Knowledge Engineering
W5 V2: Casual Mining

6
W1 V1: Big Data in Education
W1 V6: Case Study - San Pedro
W3 V4: Automated Feature Generation
W5 V1: Correlation Mining
Assignment 5
W8 V5: Conclusions and Further Directions

7
W4 V1: Knowledge Inference
W4 V2: Bayesian Knowledge Tracing
W4 V3: Performance Factors Analysis
W4 V4: Item Response Theory
W4 V5: Advanced BKT
W6 V4: State Space Diagrams
W8 V1: Discovery with Models
W8 V4: Hidden Markov Models

8
Assignment 6
W7 V5: Factor Analysis

Between-Type Concept Evaluation

UNIVERSITY AT ALBANY
State University of New York

Assignments are grouped with the upcoming lecture

Clusters that were discovered by using MVKM

1
- W2 V1: Detector Confidence
- W2 V2: Diagnostic Metrics, part 1
- W2 V3: Diagnostic Metrics, part 2
- W4 V5: Advanced BKT
- **Assignment 4**
- W5 V1: Correlation Mining
- W5 V2: Casual Mining
- W5 V3: Association Rule Mining
- W5 V4: Sequential Pattern Mining
- W5 V5: Network Analysis
- **Assignment 5**
- W6 V1: Learning Curves
- W6 V3: Scatter Plots
- W6 V4: State Space Diagrams
- W6 V5: Other Awesome EDM Visualizations
- **Assignment 6**
- W7 V2: Validation and Selection of K

2
- Week 1 Introduction
- W1 V1: Big Data in Education
- W2 V6: Types of validity
- W3 V5: Knowledge Engineering
- **Assignment 3**
- W4 V1: Knowledge Inference
- W4 V2: Bayesian Knowledge Tracing
- W4 V3: Performance Factors Analysis
- W4 V4: Item Response Theory

3
- W1 V6: Case Study - San Pedro

4
- W1 V4: Classifiers Part 2 - RapidMiner

5
- **Assignment 1**

6
- W1 V3: Classifiers Part 1

7
- W1 V2: Regressors
- **Assignment 2**
- W3 V1: Ground Truth for Behavior Detection
- W3 V2: Data Synchronization and Grain Sizes
- W3 V3: Feature Engineering
- W3 V4: Automated Feature Generation

8
- W1 V5: Classifiers Part 3
- W7 V1: Clustering
- W7 V3: Advanced Clustering Algorithms
- W7 V4: Clustering Examples
- W7 V5: Factor Analysis
- **Assignment 7**
- W8 V1: Discovery with Models
- W8 V2: Discovery with Models - Case Study
- W8 V3: Text Mining
- W8 V4: Hidden Markov Models
- W8 V5: Conclusions and Further Directions
- **Assignment 8**

Clusters discovered by using LDA topics

1
- W1 V2: Regressors
- W1 V4: Classifiers Part 2 - RapidMiner
- W1 V5: Classifiers Part 3
- **Assignment 2**
- W5 V5: Network Analysis
- W6 V1: Learning Curves
- W6 V3: Scatter Plots
- W6 V5: Other Awesome EDM Visualizations
- W7 V1: Clustering
- W7 V2: Validation and Selection of K
- W7 V3: Advanced Clustering Algorithms
- W7 V4: Clustering Examples
- **Assignment 7**
- W8 V2: Discovery with Models - Case Study
- **Assignment 8**

2
- Week 1 Introduction
- W3 V2: Data Synchronization and Grain Sizes
- W3 V3: Feature Engineering
- **Assignment 3**
- **Assignment 4**
- W8 V3: Text Mining

3
- W2 V1: Detector Confidence
- W2 V3: Diagnostic Metrics, part 2
- W5 V3: Association Rule Mining
- W5 V4: Sequential Pattern Mining

4
- W1: V3: Classifiers Part 1
- **Assignment 1**

5
- W2 V2: Diagnostic Metrics, part 1
- W2 V6: Types of validity
- W3 V1: Ground Truth for Behavior Detection
- W3 V5: Knowledge Engineering
- W5 V2: Casual Mining

6
- W1 V1: Big Data in Education
- W1 V6: Case Study - San Pedro
- W3 V4: Automated Feature Generation
- W5 V1: Correlation Mining
- **Assignment 5**
- W8 V5: Conclusions and Further Directions

7
- W4 V1: Knowledge Inference
- W4 V2: Bayesian Knowledge Tracing
- W4 V3: Performance Factors Analysis
- W4 V4: Item Response Theory
- W4 V5: Advanced BKT
- W6 V4: State Space Diagrams
- W8 V1: Discovery with Models
- W8 V4: Hidden Markov Models

8
- **Assignment 6**
- W7 V5: Factor Analysis

Conclusions

UNIVERSITY AT ALBANY
State University of New York

- We proposed a novel Multi-View Knowledge Model (MVKM)
  - MVKM outperforms other baselines in the task of student performance prediction
  - Can model students' knowledge gain from different learning materials types
  - Can effectively capture students' knowledge growth,
  - Represent similarities between different learning material types

NSF

UNIVERSITY AT ALBANY

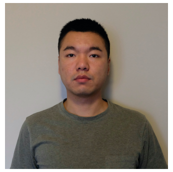
State University of New York

This paper is based upon work supported by the National Science Foundation under Grant No. 1755910.

Thank you!

Q & A

Our code are available at GitHub:
https://github.com/sz612866/MVKM-Multiview-Tensor



szhao2@albany.edu cwang25@albany.edu ssahebi@albany.edu