

Layered Evaluation of Topic-Based Adaptation to Student Knowledge

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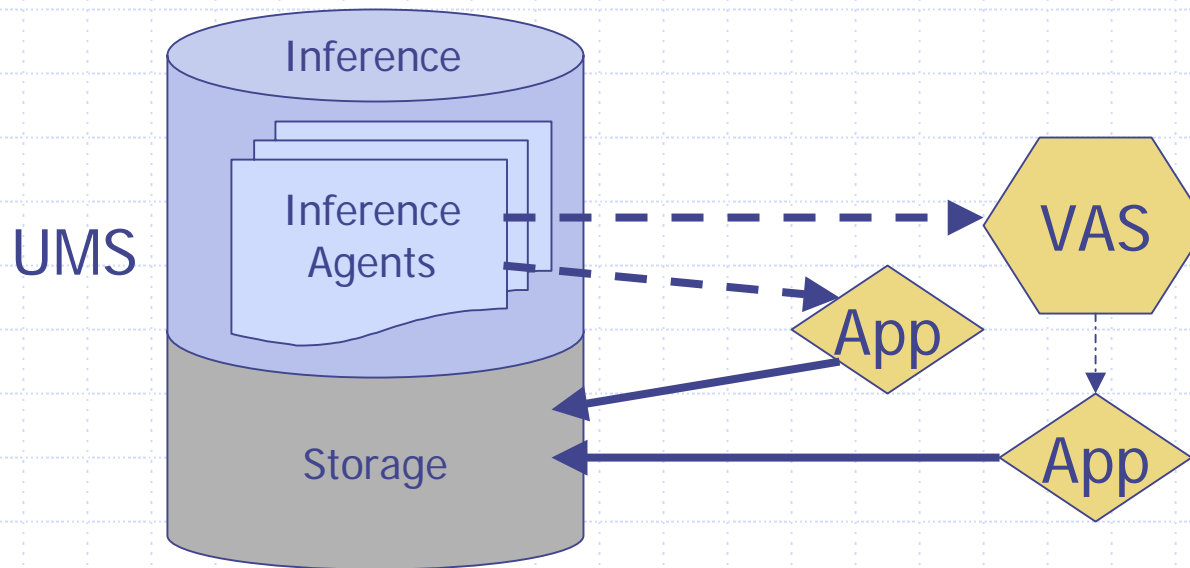


Outline

- ◆ User Modeling in Distributed Learning Environments
 - Topic-based User Modeling in CUMULATE
 - QuizPACK – Parameterized Quizzes for Self-Assessment
 - QuizGuide – an Adaptive Hypermedia Service
- ◆ Traditional “With or Without” QuizGuide Evaluation
- ◆ Layered Evaluation of CUMULATE-QuizGuide Topic-Based Adaptation
 - Evaluation of Knowledge Modeling
 - Evaluation of Adaptation Mechanism
- ◆ Conclusions

Centralized UM in DLE

- ◆ CUMULATE (Centralized User Modeling for User and Learner-AdapTive Environments)



Edit Topics

Add/Remove/Modify Topics which belong to the Scope is12

Add	Remove	ID	Name	Model URL	View URL	Filters	Scores
No	<input type="checkbox"/>	6	printing (printf)	com.lena.Default	Default.jsp	Filters	Scores
No	<input type="checkbox"/>	9	arithmetic expressions	com.lena.Default	Default.jsp	Filters	Scores
No	<input type="checkbox"/>	10	variables	com.lena.Default	Default.jsp	Filters	Scores
No	<input type="checkbox"/>	13	constants (define)	com.lena.Default	Default.jsp	Filters	Scores
No	<input type="checkbox"/>	14	loops (while)	com.lena.Default	Default.jsp	Filters	Scores
No	<input type="checkbox"/>	15	increment decrement	com.lena.Default	Default.jsp	Filters	Scores
No	<input type="checkbox"/>	16	compound assignments	com.lena.Default	Default.jsp	Filters	Scores
No	<input type="checkbox"/>	17	logical expressions	com.lena.Default	Default.jsp	Filters	Scores
No	<input type="checkbox"/>	18	loops (do while)	com.lena.Default	Default.jsp	Filters	Scores
No	<input type="checkbox"/>	19	conditionals (if else)	com.lena.Default	Default.jsp	Filters	Scores

User Model-Filters - Microsoft Internet Explorer

Edit Filters

Add	Remove	ID	Application	Activity	Activity ID	Include Results	Importance
No	<input type="checkbox"/>	84	QuizPACK	if_else1		0,1	0.600
No	<input type="checkbox"/>	85	QuizPACK	if_else2		0,1	0.400
<input checked="" type="checkbox"/>	No		Unknown				1

QuizPACK

- ◆ QuizPACK: Quizzes for Parameterized Assessment of C Knowledge
- ◆ Each question is a pattern of a simple C program. When it is delivered to a student the special parameter is dynamically instantiated by a random value within the pre-assigned borders.
- ◆ Have been used since Spring 2002 for Undergraduate course "Introduction to Programming"

DEMO

QuizPACK Evaluation

Activity - number of attempted questions.

Success - percentage of correct attempts.

Knowledge Gain - difference between pre and post test

◆ Regression: In-class Quizzes = (Activity)

$$F(1, 71) = 10.34 \quad (p = 0.002);$$

◆ Regression: Knowledge Gain = (Activity)

$$F(1, 62) = 6.1 \quad (p = 0.0163);$$

◆ Regression: Final Exam = (Success)

$$F(1, 58) = 12.84 \quad (p = 0.0007);$$

◆ ANOVA: Knowledge Gain_{Experimental} - Knowledge Gain_{Control}

$$\overline{KG}_{experimental} = 5.37 (\sigma = 2.17); \quad \overline{KG}_{control} = 1.94 (\sigma = 1.55)$$

$$F(1, 43) = 33.39 \quad (p = 7.67 * 10^{-7});$$

QuizGuide

Adaptive Annotation for Self-Assessment Quizzes

DEMO

List of annotated links to all quizzes available for a student in the current course

```
main ()
{
  int i = 10;
  int S = 0;
  do {
    i--;
    S += i;
  } while (3 < i);
}
```

What is the final value of S

S =

Submit

Questions of the current quiz, served by QuizPACK

QuizGuide Evaluation (Motivation)

	<i>QuizPACK</i>	<i>QuizGuide</i>
Active students	51(70%)	34(81%)
Average activity	110.18	245.83
Average course coverage	37.56%	52.40%
Average num. of sessions	9.18	17.28
Average session length	10.74	17.75
Average Question Persistence	1.69	6.64

Course Coverage – percentage of attempted topics

Question Persistence – number of attempts per question

QuizGuide Evaluation (Success)

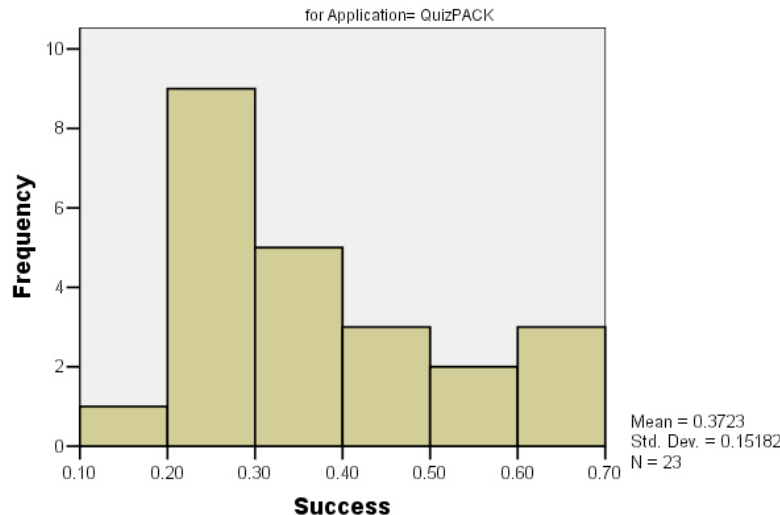
- ◆ Success (percentage of correct answers) is significantly higher for QuizGuide transactions:

$$\text{Mean}(\text{Success})_{\text{QuizGuide}} = 0.47 (\sigma = 0.15)$$

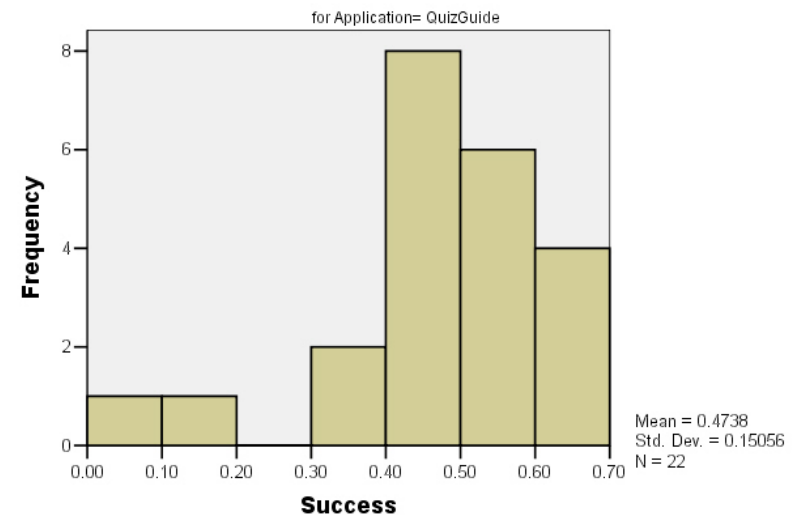
$$\text{Mean}(\text{Success})_{\text{QuizQuizPACK}} = 0.37 (\sigma = 0.15)$$

$$F(1, 43) = 5.07 \quad (p\text{-value} = 0.03);$$

Histogram



Histogram



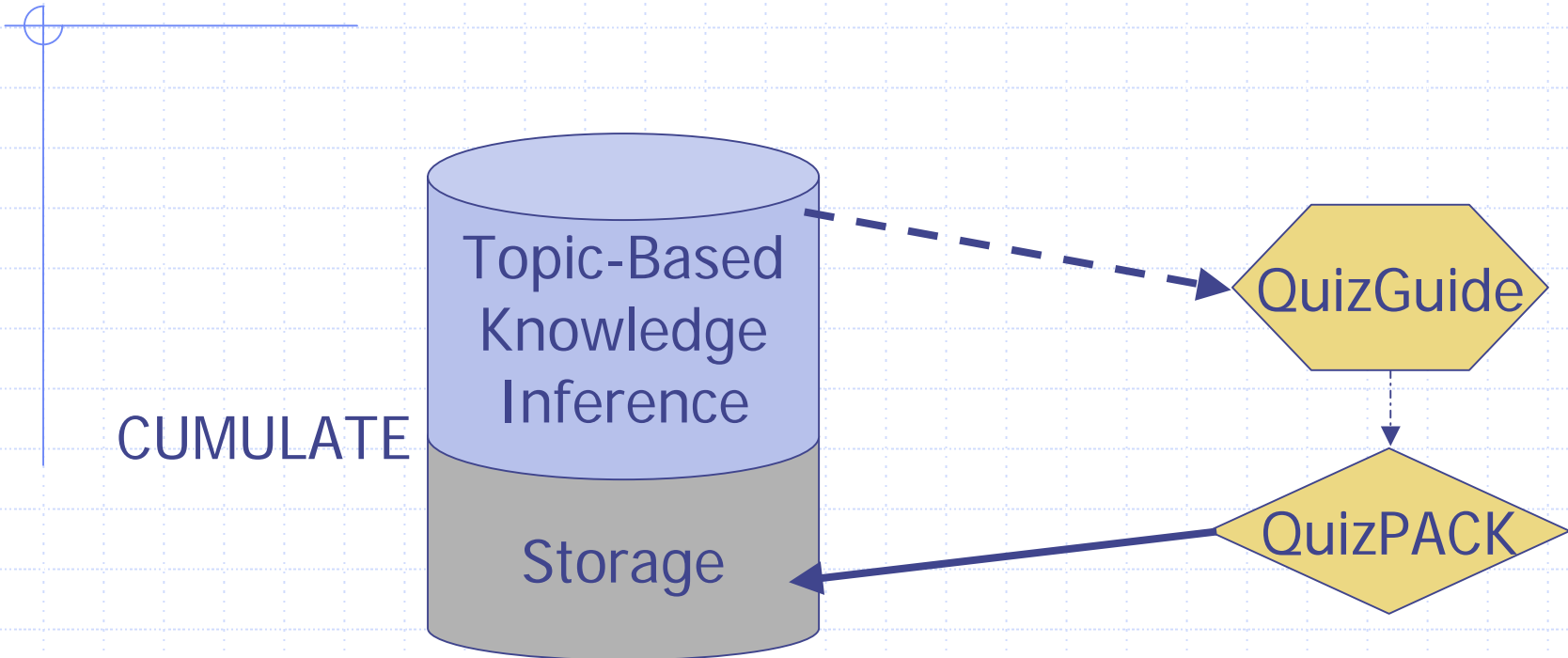
QuizGuide Evaluation (K-Gain)

$$\overline{KG}_{2003-QuizPACK} = 5.10(\sigma = 2.31)$$

$$\overline{KG}_{2004-QuizGuide} = 6.42(\sigma = 2.23)$$

$$F(1, 102) = 7.803 \text{ (} p\text{-value} = 0.006)$$

Second View on Architecture



Second View on Outline

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Layered Evaluation

- ◆ Traditional evaluation is unspecific about the object of evaluation
- ◆ Layered approach separates main phases:

Evaluation of Knowledge Modeling

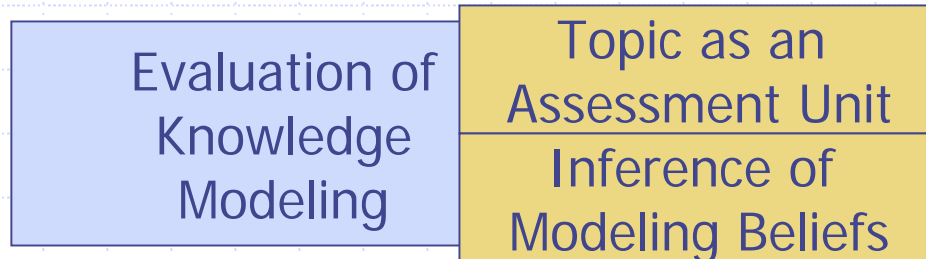
Evaluation of the Value of Adaptation

- ◆ Original Data: Two semesters of system usage by the undergraduate students:

Users	Topics	Quizzes	Questions	QuizPACK Transactions	QuizGuide Transactions
34	22	44	171	4960	5217

Evaluation of Knowledge Modeling

◆ Further Decomposition:

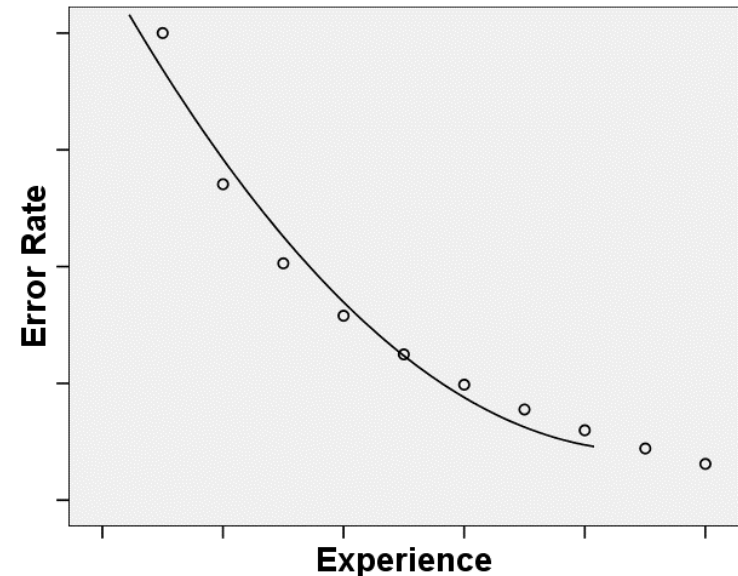
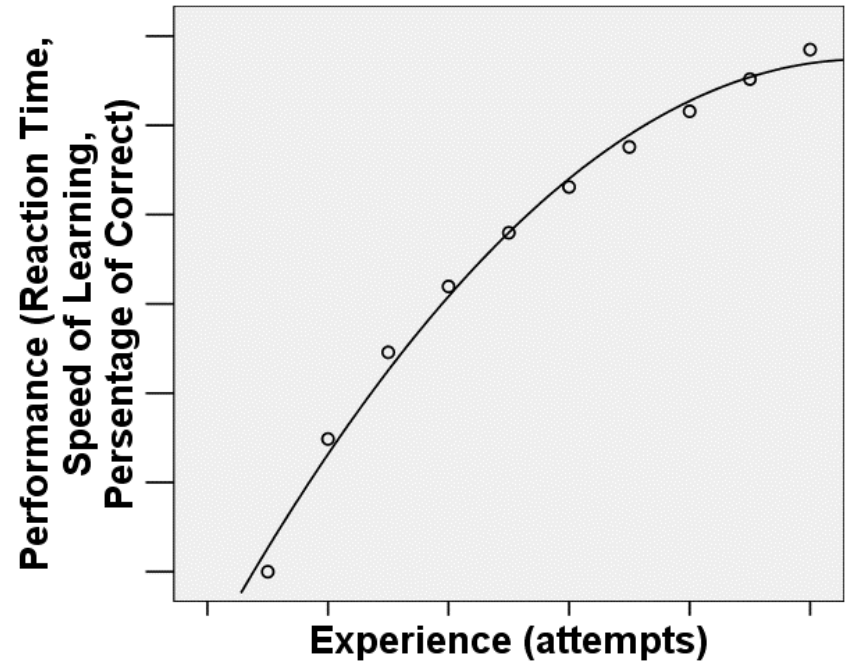


◆ Topic Evaluation – Learning Curve Analysis

◆ Inference Evaluation – Correlation Calculation

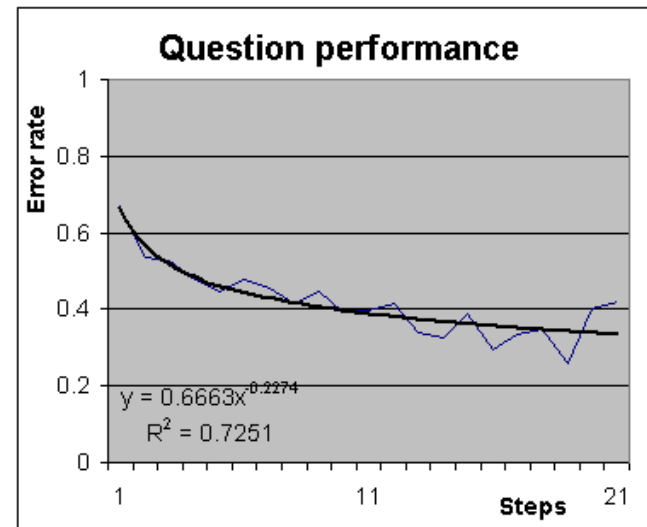
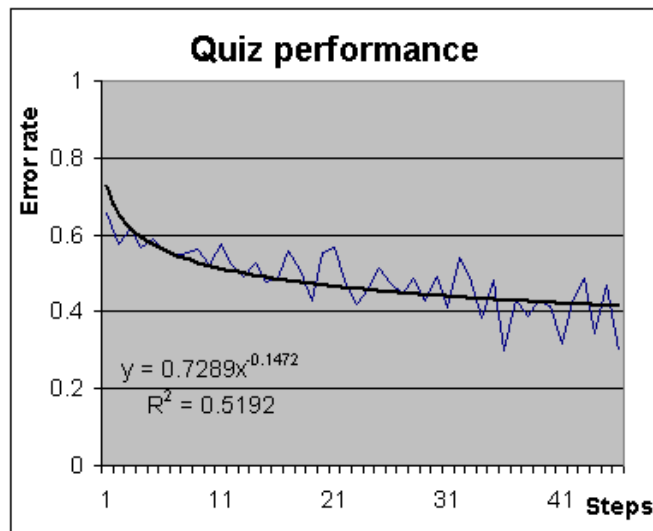
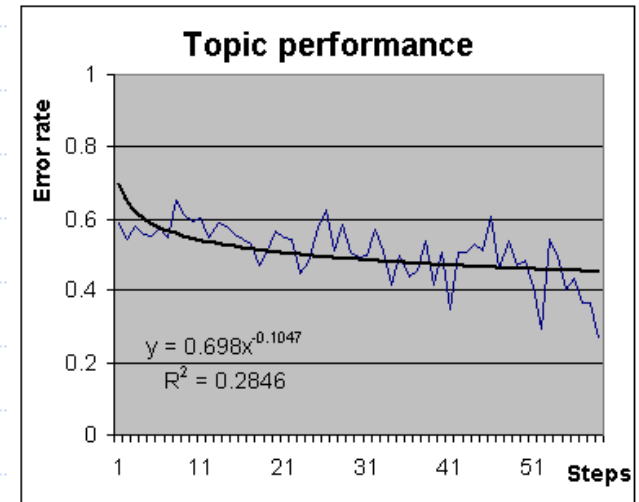
Learning Curves

- ◆ Also referred as Experience Curve and Practice Curve
- ◆ "Performance asymptotically increases with experience"
- ◆ Power Law [Newell and Rosenbloom (1981)]; Exponential Law
- ◆ Learning Curves for Evaluation of Learning Effect

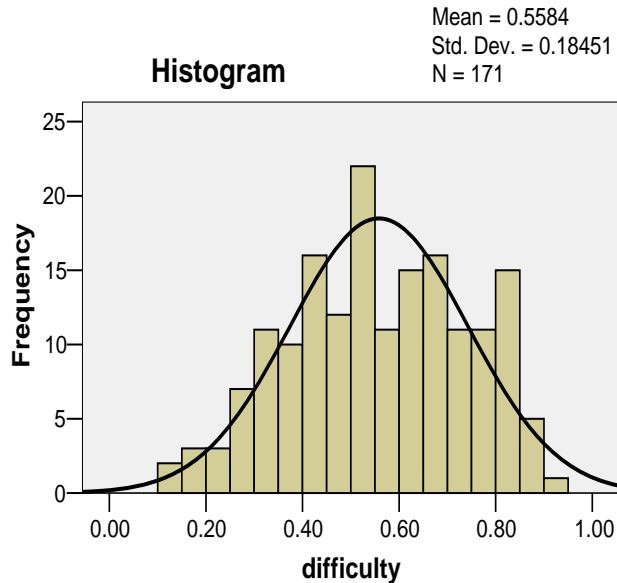


Topic as an Assessment Unit

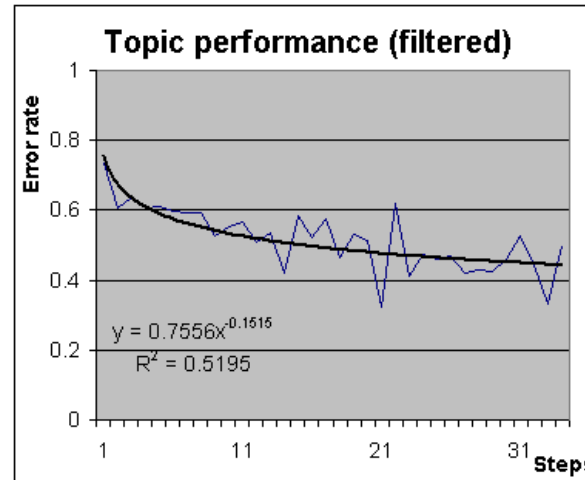
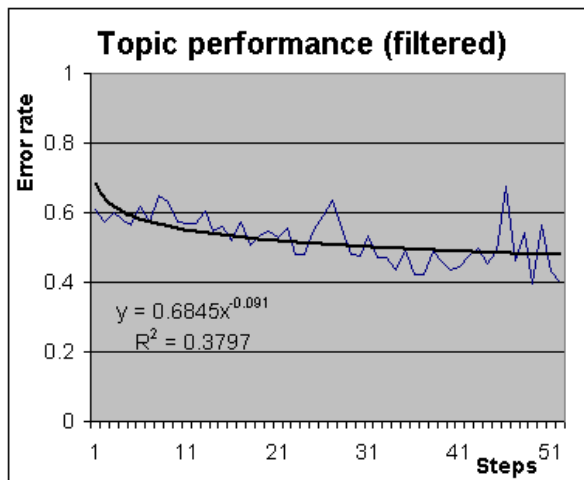
Student 1	Topic 1	attempt 1	attempt 2
	Topic 2	attempt 1	attempt 2
	Topic 3	attempt 1	attempt 2
			
Student 2	Topic 1	attempt 1	attempt 2	
	Topic 2	attempt 1	attempt 2	
	Topic 3	attempt 1	attempt 2	
			
.....				
		AVERAGE 1	AVERAGE 2
		STEP 1	STEP 2



Question Filtering



- ◆ 5th percentile = 0.16
- ◆ 25th percentile = 0.29
- ◆ 75th percentile = 0.58
- ◆ 95th percentile = 0.74



Evaluation of Inference Mechanism

◆ Formula:

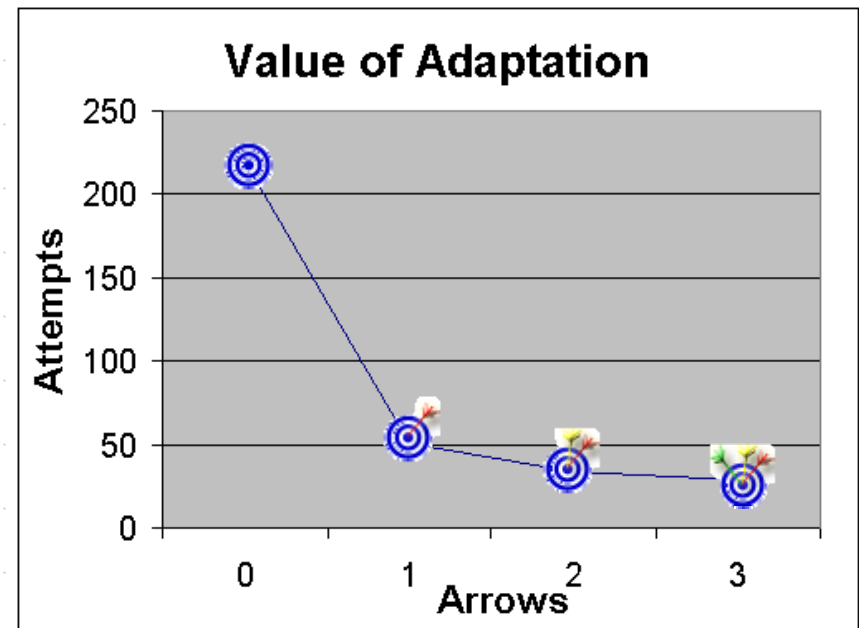
*Knowledge of the Topic –
Weighed Average Progress for
All Corresponding Resources*

◆ Correlation between UM's belief on student's knowledge and the actual behavior the student demonstrates:

Corr = -0.18

Evaluation of the Value of Adaptation

- ◆ Do students follow the adaptive hints of the system?
- ◆ 220 (zero arrows)
51 (one arrow)
34 (two arrows)
29 (three arrows)



Conclusions

- ◆ Centralized User Modeling architecture used by QuizGuide system is presented
- ◆ The attempt to evaluate topic-based adaptation to student knowledge has been reported
- ◆ Large topics have been proven to be cognitively invalid assessment units
- ◆ However, students follow the adaptive navigation of QuizGuide, using topic-based student modeling and...
- ◆ ...It increases their **motivation**,
success and
knowledge gain.

<http://www.sis.pitt.edu/~paws/>



Thank you for your questions!

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