Empirical evaluation of intelligent tutoring systems with ontological domain knowledge representation

A CASE STUDY WITH ONLINE COURSES IN HIGHER EDUCATION

ITS 2016 Zagreb 7–10 June

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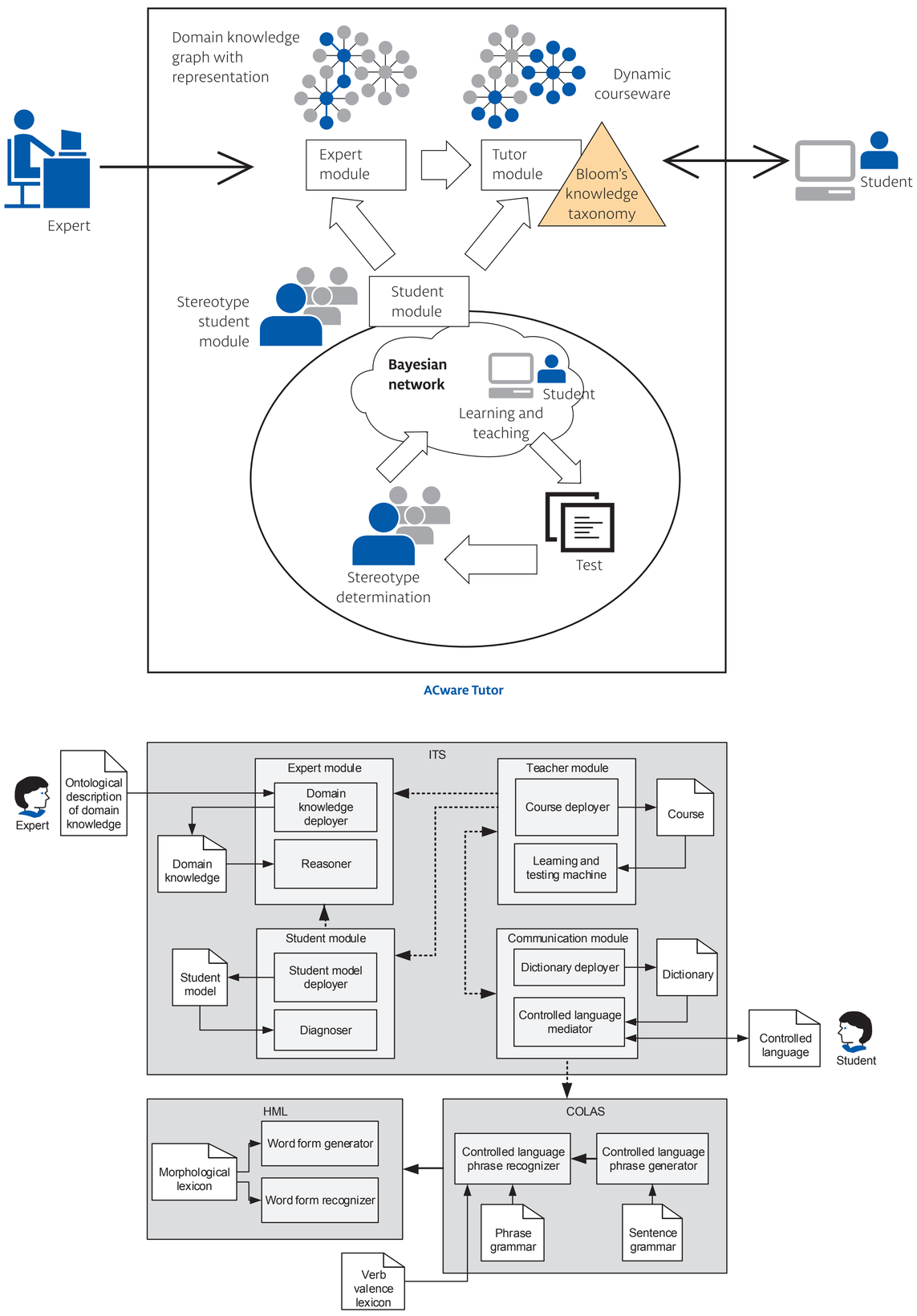
Abstract

We present results of empirical evaluation of intelligent tutoring systems (ITS) with ontological domain knowledge representation. This research was done as a first step in the process of developing a new model of intelligent tutoring system that will include all the characteristics of evaluated systems: adaptive content, communication based on controlled natural language, graphical presentation of ontological domain knowledge representation. The case study results revealed extraordinary effectiveness of evaluated adaptive intelligent tutoring systems when compared with traditional learning and teaching process.

Introduction

Design and implementation of ITSs in modern conditions, takes place under the strong influence on natural language processing and natural language communication, along with courseware that adapts learning contents to current level of student's knowledge. The authors are university level teachers with more than a decade of experience in research, development and application of ITSs (TEx-Sys [1], CoLaB Tutor [2], ACware Tutor [3], CM Tutor [4]). We plan to develop of a new fully automated ITS which will be able to tutor any declarative domain knowledge and to communicate on natural language.



Research methodology, results and findings

In this paper we present the idea and implementation of empirical evaluation of mentioned "Tutors" (CoLaB, ACware and CM) that was conducted with 103 undergraduate and graduate students from two faculties in Croatia and one faculty in Bosnia and Herzegovina. Domain knowledge that was used in this study was "Computer as a system". The goal is to apply new structural approach to learning analytics in order to calculate the effect sizes and to evaluate students' attitudes towards learning and teaching using mentioned "Tutors" – all of this will serve as a starting point for the development of the new Adaptive Courseware & Natural Language Tutor (AC & NL Tutor).

Null-hypotheses:

1. "There is no significant difference between the control group C and the treatment group T1" (NH01).
2. "There is no significant difference between the control group C and the treatment group T2" (NH02).
3. "There is no significant difference between the control group C and the treatment group T3" (NH03).

Table 1. Descriptive statistics for the case study

	Group C	Group T1	Group T2	Group T3
System	-	AC-ware	CoLab	CM Tutor
Sample size	21	28	21	33
		PRE-TEST		
Mean	24,762	28,143	28,524	29,091
Median	25	28	32	29
Standard deviation	5,603	12,776	6,524	11,762
Variance	31,390	163,238	42,562	138,335
Shapiro-Wilk (α=0.05)	W=0,917, p=0,075	W=0,989, p=0,986	W=0,927, p=0,123	W=0,960, p=0,258
		POST-TEST		
Mean	25,095	38,286	43,810	58,606
Median	24	37	46	73
Standard deviation	8,366	19,550	10,989	30,758
Variance	69,990	382,212	120,762	946,059
Shapiro-Wilk (α=0.05)	W=0,941, p=0,227	W=0,977, p=0,764	W=0,961, p=0,537	W=0,661, p=0,000
		Gain = POST-TEST – PRE-TEST		
Mean	0,333	10,143	15,286	29,515
Median	-1	5	15	38
Standard deviation	7,220	21,181	12,748	34,533
Variance	52,133	448,646	162,514	1192,508
Shapiro-Wilk (α=0.05)	W=0,954, p=0,412	W=0,966, p=0,468	W=0,977, p=0,884	W=0,803, p=0,000

Table 2. Results of testing null-hypotheses

Null-hypothesis NH01 – AC-ware			
	PRE-TEST	POST-TEST	Gain POST-TEST and PRE-TEST
F-test (critical F = 2,059) df (27 T1, 20 C)	5,200	5,461	8,606
p-value	0,000	0,000	0,000
t-value (critical t = 2,012) df= 27+20=47	-1,250	-3,201	-2,280
p-value	0,219	0,003	0,029
Effect size Cohen's d		0,586	
Confidence interval 95%		from 0,009 to 1,164 – no zero included	
Null-hypothesis NH02 - CoLab			
	PRE-TEST	POST-TEST	Gain POST-TEST and PRE-TEST
F-test (critical F = 2,124) df (20 T2, 20 C)	1,356	1,725	3,117
p-value	0,502	0,231	0,014
t-value (critical t = 2,021) df=20+20=40	-2,005	-6,209	-4,677
p-value	0,052	0,000	0,000
Effect size Cohen's d		1,443	
Confidence interval 95%		from 0,764 to 2,122 – no zero included	
Null-hypothesis NH03 – CM Tutor			
	PRE-TEST	POST-TEST	Gain POST-TEST and PRE-TEST
F-test (critical F = 2,028) df (32 T3, 20 C)	4,407	13,517	22,874
p-value	0,001	0,000	0,000
t-value (critical t = 2,007) df=32+20=52	-1,815	-5,924	-4,456
p-value	0,076	0,000	0,000
Effect size Cohen's d		1,063	
Confidence interval 95%		from 0,480 to 1,1645 – no zero included	

The results of this empirical evaluation have shown that the observed intelligent tutoring systems based on ontological domain knowledge representation are effective when compared with traditional learning and teaching process. We have conducted this case study in an everyday learning situation – with undergraduate and graduate students during their regular classes – along with all the problems that that situation brings (for example, large drop-off).

Since the case study has shown great effect sizes and promising student feedback, we will use these research findings for developing a new and unique model of intelligent tutoring system that will include all the characteristics of evaluated intelligent tutoring systems: adaptive content, communication based on controlled natural language, graphical ontological domain knowledge presentation.

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ACKNOWLEDGEMENTS

The paper is part of the work supported by the Office of Naval Research grant No. N00014-15-1-2789