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COGNITIVE LOAD IN DIFFERENT LEVELS OF REPRESENTATION OF KNOWLEDGE IN CHEMISTRY

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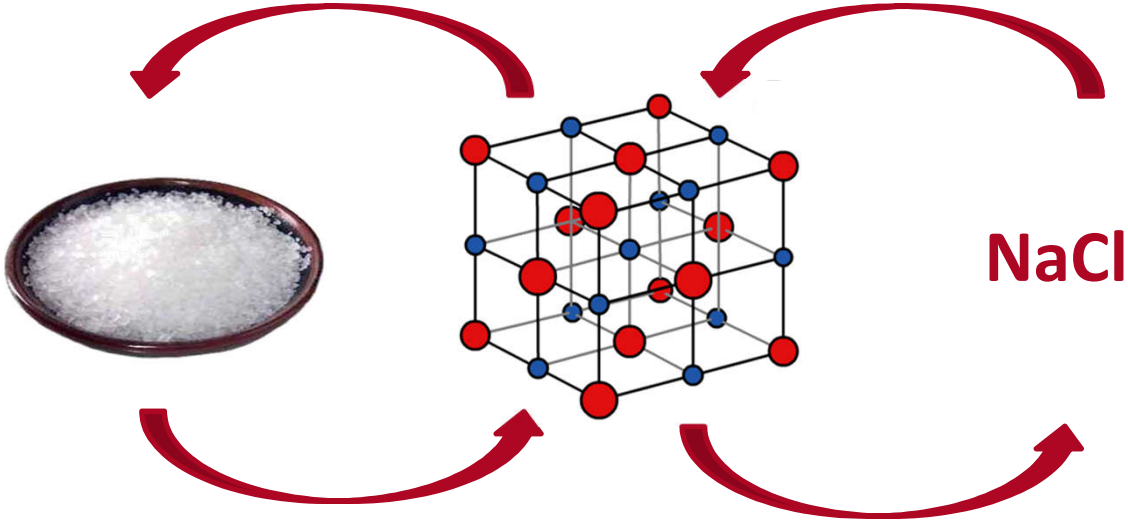
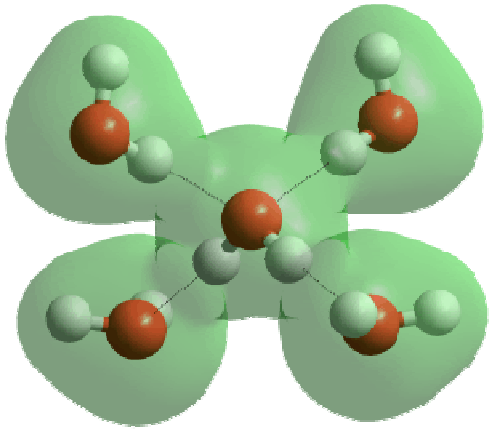


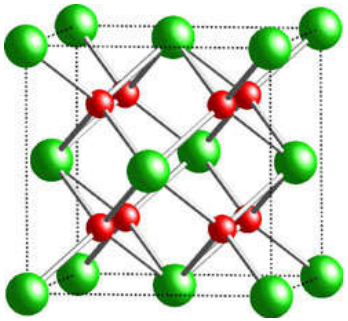
Rome, July 2012.

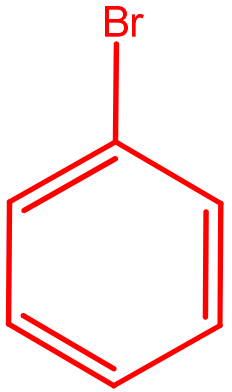
Theoretical framework

3 different levels of representation of knowledge:

Macroscopic	Sub-microscopic	Symbolic







$$2H_2 + O_2 \longrightarrow 2H_2O$$

Metodology

Aim of the research

The aim of this study was to examine students' achievements and cognitive loads in macroscopic, sub-microscopic and symbolic level of chemistry representations and to determine whether there are a statistically significant differences among them.

Research hypotheses

- There is no statistically significant difference in students' achievements at different levels of representation of knowledge in chemistry.
- There is no significant difference in cognitive load at different levels of representation of knowledge in chemistry.

Metodology

Sample:

- 43 students majoring in chemistry teaching

Measuring instruments:

- Test of 20 tasks for evaluation of knowledge

- Seven point Likert-type scale for evaluation of cognitive load

Example

1.1 What occurs when acidified solution of potassium permanganate is mixed with a solid iron(II) sulfate? Circle the letter of the correct answer.

a) solution becomes colourless d) solution becomes light green in color
b) precipitate formes c) gas releases e) there is no change

Extremely easy	Very easy	Easy	Nor dificult nor easy	Dificult	Very dificult	Extremely dificult
1	2	3	4	5	6	7

1.2 Circle the letter of the correct answer. In the aforementioned chemical reaction:

a) molecular oxygen is formed
b) iron(II) ion undergoes oxidation and permanganate ion undergoes reduction
c) iron(II) ion undergoes reduction and permanganate ion undergoes oxidation
d) mangan(IV) oxide is precipitated

Extremely easy	Very easy	Easy	Nor dificult nor easy	Dificult	Very dificult	Extremely dificult
1	2	3	4	5	6	7

1.3 Write a chemical equation that describes the aforementioned chemical reaction.

Extremely easy	Very easy	Easy	Nor dificult nor easy	Dificult	Very dificult	Extremely dificult
1	2	3	4	5	6	7

Results and discussion

Table 1 Basic statistical test indicators for measuring the total achievement and evaluation of cognitive load

Parameter	Value	
	Achievement	Cognitive load
Count	43	43
Average	23.01	4.28
Standard deviation	6.92	0.81
Minimum	13.12	2.33
Maximum	42.63	5.72
Range	29.51	3.39
Stnd. skewness	1.90	-0.87
Stnd. kurtosis	0.76	-0.69

*Highest possible score is 60 points

** Highest possible value for cognitive load is 7

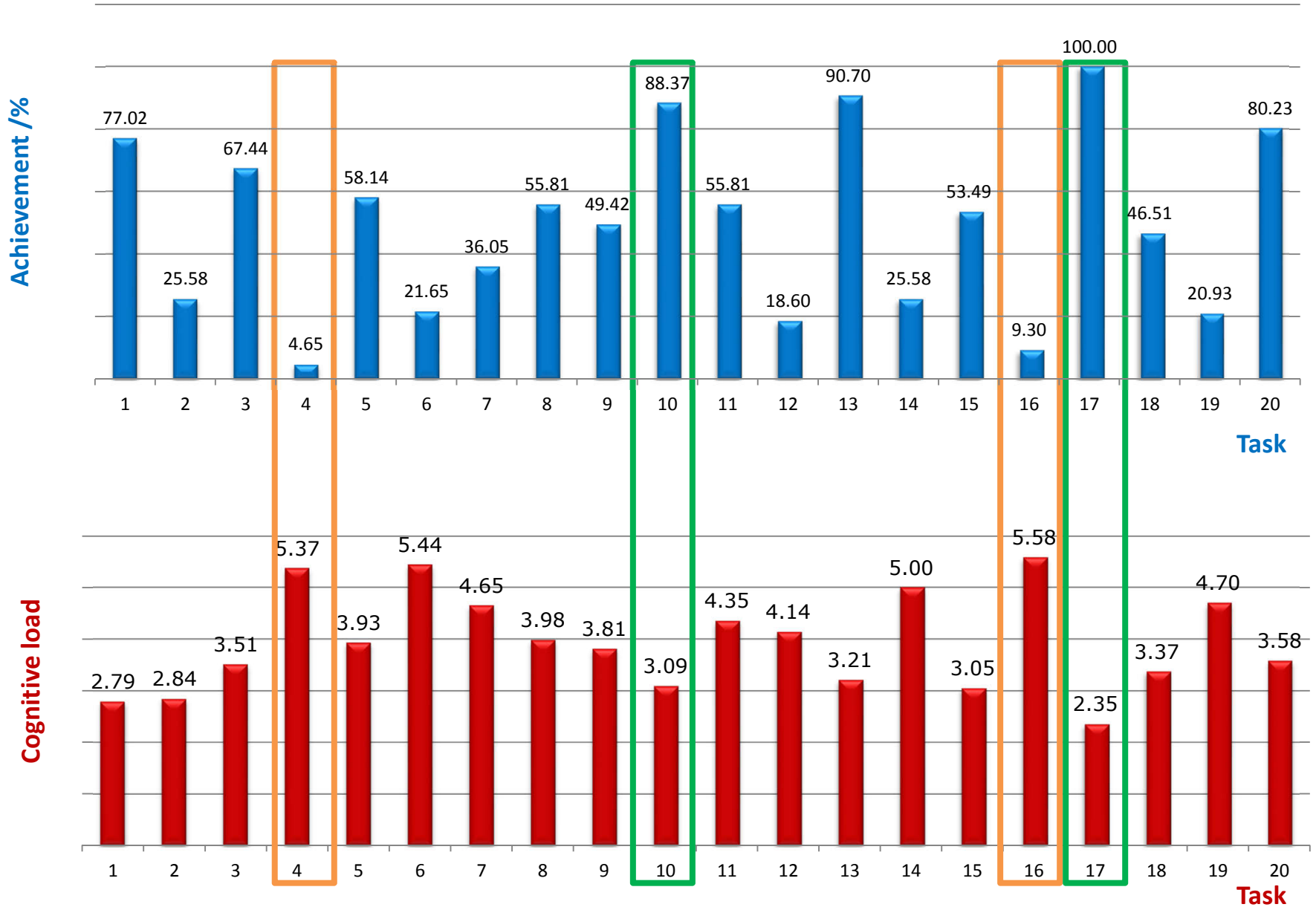
Results and discussion

Table 2 Basic statistical test indicators for measuring achievements (A) and evaluations of cognitive load (CL) by levels

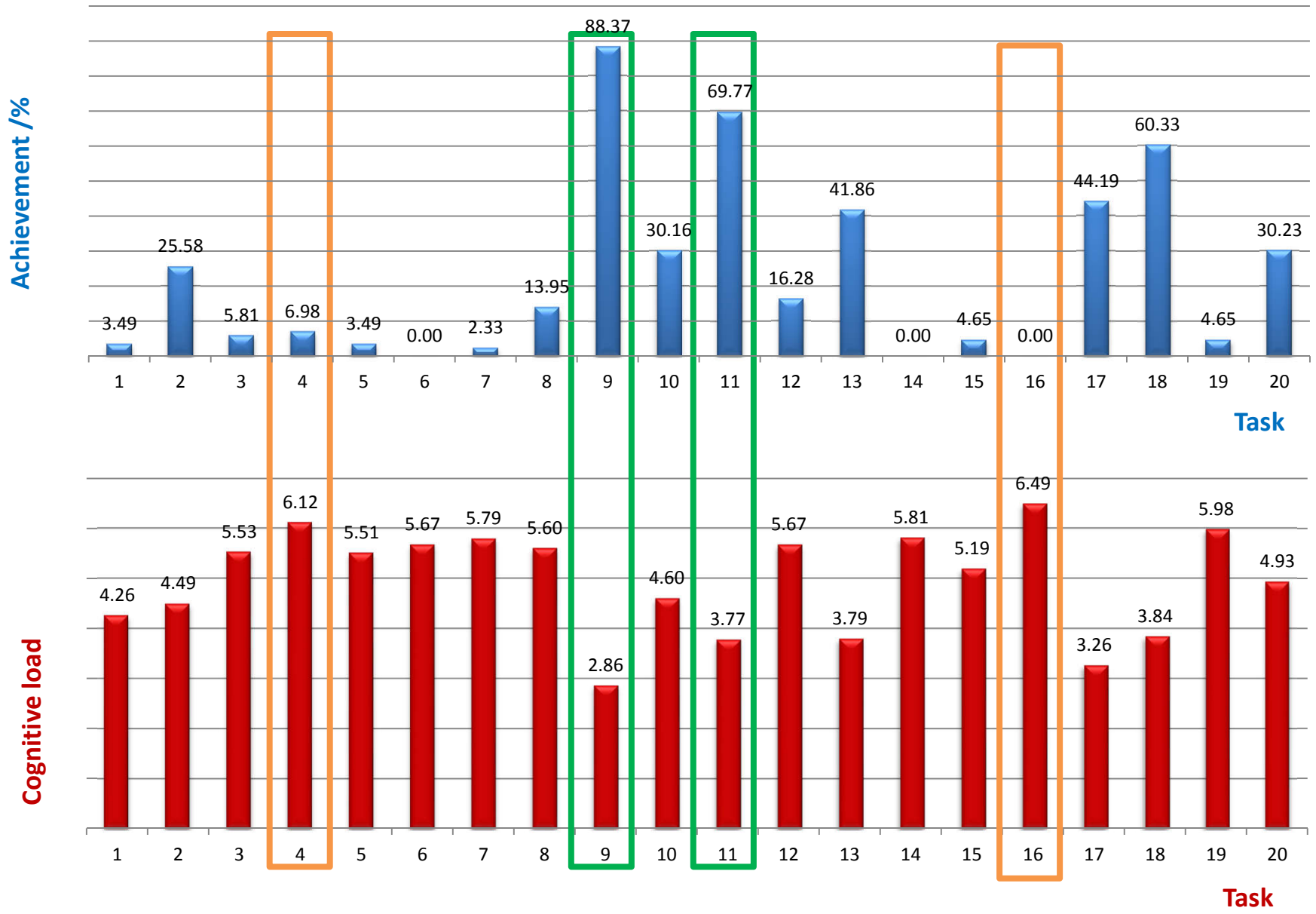
Parameter	Value					
	Macroscopic		Sub-microscopic		Symbolic	
	A	CL	A	CL	A	CL
Count	43	43	43	43	43	43
Average	9.85	3.94	4.52	4.96	8.63	3.94
Standard deviation	2.74	0.87	2.68	0.97	2.31	0.84
Minimum	4.58	2.05	0.00	3.05	4.47	1.85
Maximum	15.83	5.40	12.67	7.00	14.33	5.45
Range	11.25	3.35	12.67	3.95	9.86	3.60
Stnd. skewness	0.48	-0.21	3.09	-0.69	1.57	-1.63
Stnd. kurtosis	-0.85	-0.82	1.58	-0.75	-0.03	-0.02

*Highest possible score is 20 points by level
** Highest possible value for cognitive load is 7

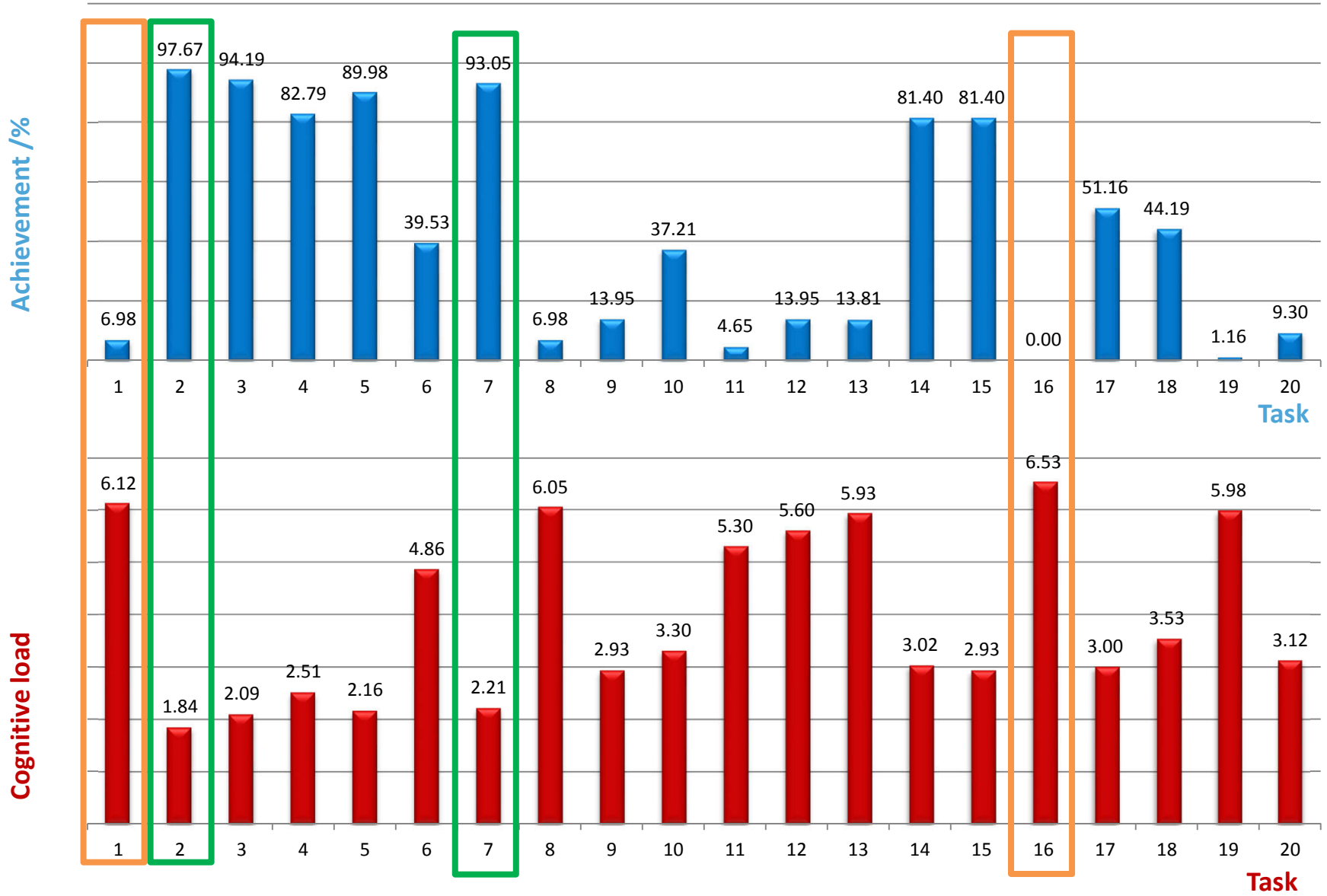
Comparative review of achievements and cognitive loads in macroscopic level by tasks



Comparative review of achievements and cognitive loads in sub-microscopic level by tasks



Comparative review of achievements and cognitive loads in symbolic level by tasks



ANOVA

Table 3 ANOVA results for acievements

Task number	Average			Variance			F-ratio	P-value
	I	II	III	I	II	III		
1.	77.02	3.49	6.98	2.08	2.85	3.07	277.26	0.0000
2.	25.58	25.58	97.67	17.11	19.49	2.33	57.41	0.0000
3.	67.44	5.81	94.19	22.48	5.01	5.01	81.51	0.0000
4.	4.65	6.98	82.79	4.54	6.64	6.97	40.46	0.0000
5.	58.14	3.49	89.98	24.92	2.85	4.50	76.50	0.0000
6.	21.65	0.00	39.53	12.63	0.00	24.47	13.63	0.0000
7.	36.05	2.33	93.05	21.82	2.33	5.04	92.94	0.0000
8.	55.81	13.95	6.98	25.25	12.29	6.64	20.37	0.0000
9.	49.42	88.37	13.95	7.59	10.52	12.29	58.80	0.0000
10.	88.37	30.16	37.21	10.52	6.30	23.92	31.96	0.0000
11.	55.81	69.77	4.65	25.25	21.59	4.54	29.51	0.0000
12.	18.60	16.28	13.95	15.50	13.95	12.29	0.17	0.8463
13.	90.70	41.86	13.81	8.64	24.92	2.71	53.84	0.0000
14.	25.58	0.00	81.40	19.49	0.00	15.50	63.86	0.0000
15.	53.49	4.65	81.40	25.47	4.54	15.50	42.77	0.0000
16.	9.30	0.00	0.00	8.64	0.00	0.00	4.31	0.0155
17.	100.00	44.19	51.16	0.00	25.25	25.58	23.47	0.0000
18.	46.51	60.33	44.19	2.85	15.03	25.25	2.28	0.1068
19.	20.93	4.65	1.16	16.94	4.54	0.58	6.51	0.0020
20.	80.23	30.23	9.30	15.64	21.59	8.64	37.35	0.0000

ANOVA

Table 4 ANOVA results for evaluations of cognitive load

Task number	Average			Variance			F-ratio	P-value
	I	II	III	I	II	III		
1.	2.79	4.26	6.12	1.93	4.58	2.06	41.84	0.0000
2.	2.84	4.49	1.84	2.43	3.78	1.14	31.48	0.0000
3.	3.51	5.53	2.09	3.78	2.68	2.51	42.99	0.0000
4.	5.37	6.12	2.51	1.95	1.87	2.21	77.49	0.0000
5.	3.93	5.51	2.16	2.92	2.45	1.90	49.79	0.0000
6.	5.44	5.67	4.86	2.54	2.27	3.27	2.81	0.0641
7.	4.65	5.79	2.21	2.80	2.41	2.36	57.04	0.0000
8.	3.98	5.60	6.05	3.26	3.10	2.43	17.44	0.0000
9.	3.81	2.86	2.93	1.58	2.84	3.64	4.52	0.0127
10.	3.09	4.60	3.30	3.04	2.77	3.64	9.16	0.0002
11.	4.35	3.77	5.30	3.80	3.94	3.16	7.07	0.0012
12.	4.14	5.67	5.60	3.41	2.89	4.15	9.27	0.0002
13.	3.21	3.79	5.93	3.88	3.55	1.40	29.98	0.0000
14.	5.00	5.81	3.02	3.48	2.11	3.55	29.10	0.0000
15.	3.05	5.19	2.93	3.05	2.30	4.97	20.18	0.0000
16.	5.58	6.49	6.53	2.53	1.16	1.06	7.83	0.0006
17.	2.35	3.26	3.00	1.85	2.86	2.86	3.73	0.0268
18.	3.37	3.84	3.53	2.57	2.81	3.59	0.80	0.4510
19.	4.70	5.98	5.98	3.03	2.40	2.98	8.37	0.0004
20.	3.58	4.93	3.12	3.77	5.45	3.39	9.08	0.0002

Summary

In this paper we have examined students' achievements and cognitive loads in different levels of representation of knowledge macroscopic, sub-microscopic and symbolic.

1. In this study it is found that there is a statistically significant difference in students' achievements among levels.

- The null hypothesis of statistically non-significant differences is confirmed only in two tasks.
- The highest average students' achievement is made at the macroscopic level (49.3%) and the lowest at the sub-microscopic level (22.6%). An average students' achievement at symbolic level is 43.2%.

2. In this study it is found that there is a statistically significant difference in cognitive loads among levels.

- The null hypothesis of statistically non-significant differences is confirmed only in two tasks.
- According to students' evaluations, the greatest cognitive load corresponds to sub-microscopic level (4.96). Students have estimated that macroscopic and symbolic level are with the same cognitive load (3.94).

Acknowledgement

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Thank you for your attention