More efficient e-learning through design: color of text and background

Janko Zufic
University of Juraj Dobrila in Pula &
Faculty of Electrical Engineering and Computing University of Zagreb, Croatia
I.M. Ronjgova 1, Pula, Croatia; Tel: +385-52-512-740; Fax: +385-52-377-550 GSM: +385-91-597-64-23
jzufic@unipu.hr

Damir Kalpic
Faculty of Electrical Engineering and Computing, University of Zagreb, Croatia
damir.kalpic@fer.hr

Structured Abstract

Background: The area of research aimed for a more efficient e-learning is slowly widening from purely technical to the areas of psychology, didactics and methodology. The question is whether the text or background color influence the efficiency of memory, i.e. learning. If the answer to that question is positive, then another question arises which combination of colors is more efficient, and which one may make the learning more difficult. This article presents results of a study on that subject.

Purpose: The basic idea of the study is to examine whether there is a difference in memorizing text in study subjects of the experimental and control group if the only variable tested is a different combination of font color and background color.
The study is divided into several phases. In the first phase, a selection of texts was made, in the second memory tests of the control group were performed, in the third, a selection was made of text and background colors, while in the fourth phase memory tests were conducted in the experimental group. Following the testing, data analyses were conducted by a single analyst.

Research Design: Experimental

Setting: The testing was conducted between November 2006 and January 2007 (control group) and between November 2008 and January 2009 (experimental group) on the Teaching college of the University of Juraj Dobrila in Pula, Croatia.

Study Sample: The testing was conducted 42 female and 2 male volunteer students of the first year of the Teaching college of the University of Juraj Dobrila in Pula, average age of the students was 19,4 years for control group and 24 female and two male volunteer students, average age was 19,4 years for experimental group.

Intervention: The study is divided into several phases. In the first phase, a selection of texts was made, in the second memory tests of the control group were performed, in the third, a selection was made of text and background colors, while in the fourth phase memory tests were conducted in the experimental group.

Control or Comparison Condition: Control group: Students were divided into four groups with 10-12 students in each group. Testing was conducted at the same time for all the four groups in the informatics/computer laboratory. The students were each time sitting on same seat and had similar conditions (as directed by the context).
The testing was conducted in such a way that students read the text for 180 seconds from the monitor, then the monitor was turned off, and without delay they wrote down using pen and paper everything they could remember from the text they read. Test subjects were allowed to read the text as many times as they could, but were not allowed to make any notes. They were also allowed to quietly repeat the words, without interfering with other students' testing.
Test subjects were told to write the text as literally as possible. Writing time was limited to 210 seconds. Following text writing, they were given a break of 300 seconds, after which they had another test. The students wrote 5 tests in a single day. Experimental group: Testing was conducted using the same parameters as the control group (same monitors, same texts with identical design, same computer laboratory, and students were positioned to look at the monitors from approximately same distance; the study was conducted in the same season, with same breaks etc.). The only difference was in combinations of text and background colors.

Data Collection and Analysis: The number of acceptable tests used in the analyses varied between 32 and 43 in the control group. Some of the subjects did not attend certain tests, and some tests were excluded from the analyses due to the notes written by the students (headache, lack of sleep etc.), or due to the results that were judged to be a significant outlier compared to the rest of the group.

Similar situation was present in the experimental group, with the number of accepted tests between 15 and 22 (with a total of 26 test subjects). Apart from the above mentioned reasons for exclusion, additional exclusion criterion in this group was weak concentration due to combination of text and background colors, which led to a somewhat higher number of excluded tests.

Test number 22 had the same color combination for the control and the experimental group. The average results of this test show that in the experimental group students wrote 42.37% of the terms, while the control group wrote 42.20%. The average standard deviation for the control group was 7.94 while in the experimental group it was somewhat higher at 9.25. This is explained by two facts: a) tests in colors result in greater difference in achieved results; and b) deviation in a smaller group has greater influence on standard deviation.

Table shows results of the tests based on text and background colors sorted from better to worse results. The results are sorted based on the black-on-white combination used in both groups. Since the results of the experimental group for that combination are slightly higher than the results in the control group, the relative difference was corrected and used.

Result analysis has shown that there was a great difference, over 40% (from +17.64 to -26.58% in comparison to the black-on-white combination), in the percent of remembered terms in individual color combinations.

Findings:

Text number	Color combination		Number of terms	Control group	Experimental group	Relative difference	Corrected relative difference
	Text	Background		% of remembered terms	% of remembered terms		
14	Black	Light Yellow	86	38,28	46,28	20,90%	17,64%
5	Yellow	Sea Green	76	39,71	47,99	20,85%	17,59%
6	Yellow	Blue	79	42,91	51,41	19,81%	16,58%
10	Black	Violet	78	51,47	61,07	18,65%	15,45%
29	Red	White	84	36,38	41,81	14,93%	11,83%
4	Green	Yellow	75	45,67	50,59	10,77%	7,78%
13	White	Red	79	40,70	45,08	10,76%	7,77%
3	Blue	Light Orange	82	38,41	41,70	8,57%	5,64%
21	Sea Green	Red	87	44,97	48,58	8,03%	5,11%
25	White	Blue	79	49,91	53,47	7,13%	4,24%
16	Black	Light Green	88	35,28	37,50	6,29%	3,43%
28	Blue	White	79	43,16	45,70	5,89%	3,03%
24	Red	Sea Green	75	51,87	54,92	5,88%	3,02%
8	Red	Light Yellow	84	38,79	40,90	5,44%	2,60%
1	Blue	Light Yellow	83	36,61	38,19	4,32%	1,50%
22	Black	White	83	42,20	43,37	2,77%	0,00%
12	Light Yellow	Red	72	47,75	48,98	2,58%	-0,19%
20	White	Black	81	49,03	50,26	2,51%	-0,26%
9	Sea Green	Blue	74	62,38	63,45	1,72%	-1,03%
18	Black	Orange	89	52,50	53,24	1,41%	-1,33%
17	Black	Rose	84	39,56	39,29	-0,68%	-3,36%
19	White	Sea Green	79	53,67	51,08	-4,83%	-7,39%
2	Violet	Light Yellow	84	39,65	37,23	-6,10%	-8,64%
7	Blue	Sea Green	66	60,03	55,19	-8,06%	-10,54%
11	Light Yellow	Black	78	56,51	50,49	-10,65%	-13,06%
27	Green	White	72	59,85	53,47	-10,66%	-13,07%
15	Black	Light Brown	88	46,70	41,13	-11,93%	-14,30%
23	Orange	Black	81	67,15	54,88	-18,27%	-20,48%
26	Orange	White	84	50,25	40,36	-19,68%	-21,85%
30	Dark Red	White	78	52,56	39,66	-24,54%	-26,58%

Conclusions: This study is part of a larger project, with the main goal to establish the elements of more efficient e-learning. On one hand, the control group used the standard color combination (black font on white background), while the experimental group used different color combinations of texts and backgrounds. The achieved results have shown which color combinations for font and background should be used to achieve better memorization effect. The difference in memorizing could be rather great, up to 40%, so the combination of font and background color should be taken into consideration in preparation of e-materials for e-learning.

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http://wwww.carnet.hr/referalni/obrazovni/ iom/ - (access 31.08.2009.)
Mateljan, V., Širanović, Ž., Šimović, V. Prjedlog modela za oblikovanje multimedjskih web nastavnih sadržaja prema pedagoškoj praksi u Republici Hrvatskoj, *Journal: Informatologia* 42, 1 (38-44) (*in Croatian*), 2009.
Shire - http://www.shire.net/learnwebdesign/nocss/fonts.htm (access 31.8.2009.)
Weinman, L: *The Browser-Safe Web Palette*, http://www.lynda.com/resources/webpalette.aspx (access 31.08.2009.)
Zarevski, P. *Psihologija učenja i pamćenja*, Naklada slap, Jastrebarsko (*in Croatian*), 2001.
Zufic, J. Kalpic, D. (2007a) More Efficient Learning on Web Courseware Systems? *World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education,* Qubec City, Canada, 2007. (pp 6707-6716)
Zufic, J. Kalpic, D. (2007b) Design Workshop for use of WebCT in Education of Teachers, *29th International Conference on Information Technology Interfaces, Knowledge Discovery in Education and Business* Cavtat, Dubrovnik, Croatia. (pp 393-398)

Abstract: Changes in technology and new information technologies confront teachers with the challenge to create and present educational materials through a regular web site or through some of the courseware tools. During preparation of the e-learning material, they need to take into consideration the design that would lead to a more efficient e-learning. One of the elements in educational materials design is the choice of color for text and background. We are presenting the results of a study using thirty color combinations of text and background. A list of color combinations that would increase the efficiency of learning by 17%, or decrease it by 26% in comparison to a standard black (text) and white (background) combination is presented.

Introduction

The area of research aimed for a more efficient e-learning is slowly widening from purely technical to the areas of psychology, didactics and methodology. Apart from the fact that the contents of teaching material should be good and interesting, it has been observed that students learn better when the teaching material is adjusted to their intelligence level (Zufic & Kalpic 2007a). If the educational material is presented through some of the courseware tools, and the mentor is leading students through the educational material, then it is important that the mentor, apart from the necessary professional skills, demonstrate humane characteristics such as helpfulness, kindness, accessibility, patience, tolerance, as well as good communication skills (Zufic & Kalpic 2007b). However, with or without a mentor, teaching material needs to be remembered and learned.

Memory is the ability to adopt, retain and use information, while learning primarily remains at the first component – knowledge adoption (Zarevski 2001). Without entering into theoretical discussion on psychology of memory and learning, teachers who prepare teaching material need practical instructions, on principles of which they could create the teaching material. Mateljan, Siranovic and Simovic suggest segmentation of the content as one of the principles, in other words they believe that multimedia contents is better learned if it is divided into smaller parts than if it is given as a unique, continuous unit (Mateljan, Siranovic, Simovic 2009). The question is whether the text or background color influence the efficiency of memory, i.e. learning. If the answer to that question is positive, then another question arises which combination of colors is more efficient, and which one may make the learning more difficult. This article presents results of a study on that subject.

Research

Idea, goal and methodology of the study

The basic idea of the study is to examine whether there is a difference in memorizing text in study subjects of the experimental and control group if the only variable tested is a different combination of font color and background color.

The study is divided into several phases. In the first phase, a selection of texts was made, in the second memory tests of the control group were performed, in the third, a selection was made of text and background colors, while in the fourth phase memory tests were conducted in the experimental group. Following the testing, data analyses were conducted by a single analyst.

Choosing texts

Thirty texts were chosen. The chosen texts were of approximately same length, 106-119 words, without tables, photographs, graphic symbols or frames. Texts were taken off the Internet, and thematically were mostly from the area of popular science, but were not connected to each other in order to reduce the chance of information transfer.

All texts were interesting, containing very small number of new/expert words (up to 5 in each text), published three to five years earlier, which renders insignificant the possibility that some of the test subjects earlier had read and memorized the text. Considering the number of words and the time allowed to memorize/learn, after the first day of testing it was established that it was better to use the number of terms in the text, and not the number of words. Some test subjects were writing only terms (verbs, nouns, adjectives, numbers, pronouns), and excluding conjunctions, adverbs and prepositions, while some others wrote all the words. Tne number of terms within a text was variable, 66-89 per text.

Number of terms and thematic areas are listed in Table 1.

Text number	Text title	Word number	Term number	Text themes
1	Cow	111	83	Popular science
2	Food	106	84	Popular science
3	Lake	111	82	Popular science
4	Centripede	112	75	Popular science
5	Flight	109	76	Popular science
6	Baby	110	79	Popular science
7	Story	111	66	Invented story
8	Velebit	111	84	Interesting newspaper article
9	Mars	111	74	Popular science
10	Monkeys	111	78	Popular science
11	Ethiopia	114	78	Interesting travel article
12	Mud	113	72	Popular science
13	Hypnosis	109	79	Popular science
14	Fuel	119	86	Popular science
15	Ants	115	88	Popular science
16	Paper	115	88	Popular science
17	Bible	116	84	Popular science
18	Watch	114	89	Popular science
19	Jelly fish	111	79	Popular science
20	Corn	111	81	Popular medicine
21	Beak	116	87	Popular science
22	Ear	114	83	Popular science
23	Rabbit	113	81	Popular science
24	Boat	107	75	Popular history
25	Aspirin	110	79	Popular science
26	Algae	114	84	Popular science
27	Dodo	114	72	Popular science
28	Mem	112	79	Popular science
29	Tree	114	84	Popular science
30	Mammals	114	78	Popular science

Table 1. Number of words, terms and text themes

The text that was to be memorized was written and shown in MS Word. Text font was classic, Verdana, since it is supported by majority of computers (Shire, 2009), font size 12, black, while background was white. The text was aligned left. Zoom was set to 150%. It was not necessary to use either horizontal or vertical scrolling in order to read the text. Monitor type was CRT, physical size was 17" diagonal. Monitor resolution was 1024x768, and was identical on all monitors. Students' eyes were approximately 60 cm from the monitor screen.

Memory testing of the control group

The testing was conducted between November 2006 and January 2007, and was attended by 44 (42 female and 2 male) volunteer students of the first year of the Teaching college of the University of Juraj Dobrila in Pula. Average age of the students was 19,4 years. Average number of collected points (which is proportional to high school success) of the enrolled students was 278 with standard deviation of 43,3. Students were divided into four groups with 10-12 students in each group. Testing was conducted at the same time for all the four groups in the informatics/computer laboratory. The students were each time sitting on same seat and had similar conditions (as directed by the context).

The testing was conducted in such a way that students read the text for 180 seconds from the monitor, then the monitor was turned off, and without delay they wrote down using pen and paper everything they could remember from the text they read. Test subjects were allowed to read the text as many times as they could, but were not allowed to make any notes. They were also allowed to quietly repeat the words, without interfering with other students' testing.

Test subjects were told to write the text as literally as possible. Writing time was limited to 210 seconds. Following text writing, they were given a break of 300 seconds, after which they had another test. The students wrote 5 tests in a single day. Unfortunately, due to their other obligations, testing could not be conducted each day,

and could not be conducted at the same time of the day. The students were not instructed on mnemotechniques they could use.

The students wrote their name and family name, text they memorized and, eventually, a note if they did not feel well for some reason (lack of sleep, headache or similar difficulties).

Experimental group

Testing of the experimental group was conducted between November 2008 and January 2009, in a group of 26 (24 female and two male) volunteer students. Average age was 19,4 years. The number of collected points at the time of enrollment to the University was 270 with standard deviation of 30,7.

Testing was conducted using the same parameters as the control group (same monitors, same texts with identical design, same computer laboratory, and students were positioned to look at the monitors from approximately same distance; the study was conducted in the same season, with same breaks etc.). The only difference was in combinations of text and background colors. One text (#22) had the same combination of colors (black on white) as in the control group in order to be able to compare the groups.

Choice of text and background colors

Primary colors at drawing (reflective light) are red, yellow and blue, while the primary colors on monitor (incident light) are red, green and blue. Since the text was shown on a monitor, we used the RGB color model. The chosen combinations of text and background colors for the 30 texts are shown in Table 2.

Text number	Text				Background			
	Color	Red	Green	Blue	Color	Red	Green	Blue
1	Blue	0	0	255	Light Yellow	255	255	153
2	Violet	128	0	128	Light Yellow	255	255	153
3	Blue	0	0	255	Light Orange	255	133	0
4	Green	0	128	0	Yellow	255	255	0
5	Yellow	255	255	0	Sea Green	51	153	102
6	Yellow	255	255	0	Blue	0	0	255
7	Blue	0	0	255	Sea Green	51	153	102
8	Red	255	0	0	Light Yellow	255	255	153
9	Sea Green	51	153	102	Blue	0	0	255
10	Black	0	0	0	Violet	128	0	128
11	Light Yellow	255	255	153	Black	0	0	0
12	Light Yellow	255	255	153	Red	255	0	0
13	White	255	255	255	Red	255	0	0
14	Black	0	0	0	Light Yellow	255	255	153
15	Black	0	0	0	Light Brown	255	204	153
16	Black	0	0	0	Light Green	204	255	204
17	Black	0	0	0	Rose	255	153	204
18	Black	0	0	0	Orange	255	102	0
19	White	255	255	255	Sea Green	51	153	102
20	White	255	255	255	Black	0	0	0
21	Sea Green	51	153	102	Red	255	0	0
22	Black	0	0	0	White	255	255	255
23	Orange	255	102	0	Black	0	0	0
24	Red	255	0	0	Sea Green	51	153	102
25	White	255	255	255	Blue	0	0	255
26	Orange	255	102	0	White	255	255	255
27	Green	0	128	0	White	255	255	255
28	Blue	0	0	255	White	255	255	255
29	Red	255	0	0	White	255	255	255
30	Dark Red	128	0	0	White	255	255	255

Table 2. Choice of text and background colors used in the study.

All background colors were simple (CARNet 2006), monochromatic and without pattern so that text could be readable. Background colors (except #10) were from the so-called browser-safe color palette. Colors from the browser-safe palette were used because these are the only colors that maintain the same hue on PC and Mac computers in Netscape, Mosaic and Internet Explorer browsers. Font colors were also from the browser-safe palette (except #2, 4, 27 and 30), since lack of use of these colors could cause dithering of the two colors (Weinman, 2009).

Results

Achieved results are shown in Table 3.

Text		Control group				Experimental group			
Text number	Term number	Number of test subjects	Average number of written terms	% of written terms	Standard deviation	Number of test subjects	Average number of written terms	% of written terms	Standard deviation
1	83	41	30,39	36,61	4,92	20	31,70	38,19	6,33
2	84	43	33,30	39,65	7,69	22	31,27	37,23	7,75
3	82	34	31,50	38,41	7,17	21	34,19	41,70	8,23
4	75	40	34,25	45,67	6,49	18	37,94	50,59	10,70
5	76	39	30,18	39,71	7,08	17	36,47	47,99	12,91
6	79	40	33,90	42,91	7,02	18	40,61	51,41	9,06
7	66	42	39,62	60,03	6,54	21	36,43	55,19	8,34
8	84	43	32,58	38,79	7,27	17	34,35	40,90	8,89
9	74	43	46,16	62,38	8,48	22	46,95	63,45	10,06
10	78	42	40,14	51,47	6,98	22	47,64	61,07	9,17
11	78	40	44,08	56,51	9,09	21	39,38	50,49	8,66
12	72	37	34,38	47,75	7,09	19	35,26	48,98	9,43
13	79	39	32,15	40,70	7,41	18	35,61	45,08	9,94
14	86	39	32,87	38,28	8,44	15	39,80	46,28	9,26
15	88	41	41,10	46,70	8,21	21	36,19	41,13	10,49
16	88	40	31,05	35,28	5,26	19	33,00	37,50	10,91
17	84	39	33,23	39,56	8,77	17	33,00	39,29	7,85
18	89	43	46,72	52,50	8,19	19	47,47	53,24	9,68
19	79	40	42,40	53,67	8,03	20	40,35	51,08	8,82
20	81	42	39,71	49,03	8,64	21	40,71	50,26	10,12
21	87	39	39,13	44,97	7,66	21	40,52	48,58	11,40
22	83	41	35,02	42,20	9,75	17	36,00	43,37	10,30
23	81	43	54,40	67,15	10,25	20	44,45	54,88	9,79
24	75	41	38,90	51,87	9,97	21	41,19	54,92	9,95
25	79	42	39,43	49,91	7,91	21	42,24	53,47	7,99
26	84	43	42,21	50,25	8,26	21	33,90	40,36	9,01
27	72	42	43,10	59,85	8,15	22	38,50	53,47	5,68
28	79	41	34,10	43,16	8,94	20	36,10	45,70	8,30
29	84	32	30,56	36,38	7,81	17	35,12	41,81	10,27
30	78	32	41,00	52,56	10,74	16	30,94	39,66	8,15
		Average	37,58	47,13	7,94	Average	37,91	47,58	9,25

Table 3. Results of the study

Result analyses

The initial analysis has shown that the groups were similar in terms of age, gender and number of accumulated points at the time of enrollment in the University. The study was conducted under similar conditions, therefore we assume that the achieved results were influenced only by the measured variable, which is the

combination of text and background colors. The number of acceptable tests used in the analyses varied between 32 and 43 in the control group (with a total of 44 subjects). Some of the subjects did not attend certain tests, and some tests were excluded from the analyses due (less than 20 written terms) to the notes written by the students (headache, lack of sleep etc.), or due to the results that were judged to be a significant outlier compared to the rest of the group.

Similar situation was present in the experimental group, with the number of accepted tests between 15 and 22 (with a total of 26 test subjects). Apart from the above mentioned reasons for exclusion, additional exclusion criterion in this group was weak concentration due to combination of text and background colors, which led to a somewhat higher number of excluded tests.

Test number 22 had the same color combination for the control and the experimental group. The average results of this test show that in the experimental group students wrote 42.37% of the terms, while the control group wrote 42.20%. The difference is minimal and presents one terms, or a relative difference of 2.77%.

The average standard deviation for the control group was 7.94 while in the experimental group it was somewhat higher at 9.25. This is explained by two facts: a) tests in colors result in greater difference in achieved results; and b) deviation in a smaller group has greater influence on standard deviation.

The average number of written terms for the entire battery of 30 tests in the control and experimental group were almost identical (47.13% vs. 47.58%, respectively).

Table 4 shows results of the tests based on text and background colors sorted from better to worse results. The results are sorted based on the black-on-white combination used in both groups. Since the results of the experimental group for that combination are slightly higher than the results in the control group, the relative difference was corrected and used.

| Text number | Color combination | | Number of terms | Control group | Experimental group | Relative difference | Corrected relative difference |
	Text	Background		% of remembered terms	% of remembered terms		
14	Black	Light Yellow	86	38,28	46,28	20,90%	17,64%
5	Yellow	Sea Green	76	39,71	47,99	20,85%	17,59%
6	Yellow	Blue	79	42,91	51,41	19,81%	16,58%
10	Black	Violet	78	51,47	61,07	18,65%	15,45%
29	Red	White	84	36,38	41,81	14,93%	11,83%
4	Green	Yellow	75	45,67	50,59	10,77%	7,78%
13	White	Red	79	40,70	45,08	10,76%	7,77%
3	Blue	Light Orange	82	38,41	41,70	8,57%	5,64%
21	Sea Green	Red	87	44,97	48,58	8,03%	5,11%
25	White	Blue	79	49,91	53,47	7,13%	4,24%
16	Black	Light Green	88	35,28	37,50	6,29%	3,43%
28	Blue	White	79	43,16	45,70	5,89%	3,03%
24	Red	Sea Green	75	51,87	54,92	5,88%	3,02%
8	Red	Light Yellow	84	38,79	40,90	5,44%	2,60%
1	Blue	Light Yellow	83	36,61	38,19	4,32%	1,50%
22	Black	White	83	42,20	43,37	2,77%	0,00%
12	Light Yellow	Red	72	47,75	48,98	2,58%	-0,19%
20	White	Black	81	49,03	50,26	2,51%	-0,26%
9	Sea Green	Blue	74	62,38	63,45	1,72%	-1,03%
18	Black	Orange	89	52,50	53,24	1,41%	-1,33%
17	Black	Rose	84	39,56	39,29	-0,68%	-3,36%
19	White	Sea Green	79	53,67	51,08	-4,83%	-7,39%
2	Violet	Light Yellow	84	39,65	37,23	-6,10%	-8,64%
7	Blue	Sea Green	66	60,03	55,19	-8,06%	-10,54%
11	Light Yellow	Black	78	56,51	50,49	-10,65%	-13,06%
27	Green	White	72	59,85	53,47	-10,66%	-13,07%
15	Black	Light Brown	88	46,70	41,13	-11,93%	-14,30%
23	Orange	Black	81	67,15	54,88	-18,27%	-20,48%
26	Orange	White	84	50,25	40,36	-19,68%	-21,85%
30	Dark Red	White	78	52,56	39,66	-24,54%	-26,58%

Table 4. Comparison between control and experimental group.

Result analysis has shown that there was a great difference, over 40% (from +17.64 to -26.58% in comparison to the black-on-white combination), in the percent of remembered terms in individual color combinations.

Conclusion

This study is part of a larger project, with the main goal to establish the elements of more efficient e-learning. On one hand, the control group used the standard color combination (black font on white background), while the experimental group used different color combinations of texts and backgrounds. The achieved results have shown which color combinations for font and background should be used to achieve better memorization effect. The difference in memorizing could be rather great, up to 40%, so the combination of font and background color should be taken into consideration in preparation of e-materials for e-learning.

Reference

CARNet's Reference center – Development of Educational Materials http://wwww.carnet.hr/referalni/obrazovni/ iom/ - (access 31.08.2009.)

Mateljan, V., Širanović, Ž., Šimović, V. (2009) Prjedlog modela za oblikovanje multimedjskih web nastavnih sadržaja prema pedagoškoj praksi u Republici Hrvatskoj, *Journal: Informatologia* 42, 1 (38-44) (*in Croatian*)

Shire - http://www.shire.net/learnwebdesign/nocss/fonts.htm (access 31.8.2009.)

Weinman, L: *The Browser-Safe Web Palette*, http://www.lynda.com/resources/webpalette.aspx (access 31.08.2009.)

Zarevski, P. (2001) *Psihologija učenja i pamćenja*, Naklada slap, Jastrebarsko (*in Croatian*)

Zufic, J. Kalpic, D. (2007a) More Efficient Learning on Web Courseware Systems? *World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education,* Qubec City, Canada, 2007. (6707-6716)

Zufic, J. Kalpic, D. (2007b) Design Workshop for use of WebCT in Education of Teachers, *29th International Conference on Information Technology Interfaces, Knowledge Discovery in Education,…Business* Cavtat, Dubrovnik, Croatia. (393-398)