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Survey Paper

The Position of Teaching Materials on the Monitor and its Effect on the E-learning Success

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Abstract

There are various elements in designing e-teaching materials that could have an impact in raising the efficiency of e-learning. This paper is based on the experiments aiming to investigate whether there are certain positions on the monitor in which students are able to better perceive and/or remember e-teaching materials. Our research was carried out at the Juraj Dobrila University of Pula. Participants were first year students attending the teacher education programme (aged 19.5 – 20.5). The research design included two pre-experimental groups and one experimental group. The monitor was virtually divided into 24 zones. Students read the teaching material displayed on the screen; in each reading four texts in different positions were used. The relative ease/difficulty of remembering the text was taken into account by introducing different ponders to each text. Regarding the memory efficiency, our results show statistically significant differences between certain screen positions (these differences ranged from +29.6% to -42.6% from the average result).
Keywords: efficient e-learning, text position on the screen

1. Introduction

Every research project that intends to establish which factors enable more efficient e-learning is exceptionally useful for teachers and designers of teaching materials. They create and adapt e-learning materials based on research results to enable users to learn easier, faster and more efficiently. In traditional forms of learning there are many factors that affect efficient teaching, and in the e-learning such factors are even more numerous.

In preparation of the E-teaching materials, teachers attempt to create contents that would be logical and understandable to the students. However, in the process they often copy teaching materials from the existing textbooks or PowerPoint presentations without taking into account the fact that E-teaching is a different medium and requires different teaching paradigm. Development of technology led to a development of informatics systems for E-education that gradually, more and more follow pedagogical, didactic, psychological and methodological standards present in the traditional education.

Bloom [4] gave a huge contribution to the efficient teaching when he established that the most efficient teaching is based on an individual, tutor-based approach between a teacher and a student. The goal of the efficient teaching is defined by Bloom's 2-sigma problem, which motivates the researcher to discover types of teaching that will be efficient as much as the tutoring type of teaching. Bloom researched efficiency of teaching under traditional, mastery *learning*[1] and *tutoring system*[2] of teaching. In his research, the traditional form of teaching was the least efficient, while the tutoring approach was the most efficient.

In e-learning, adaptive systems for teaching offer an advanced form of environment that attempts to fulfill different needs of students [7]. The system is dynamically adapting in such a way as to create the conditions that will support a student in learning in the best possible way. Rassmunsen [25] concluded that teaching system can define student's learning habits, and that is can be adapted for more efficient teaching of students. Among other potential causes, intellectual abilities may be the causative factor for differential success in learning among students [23].

Meta-analyses in the area of the e-learning efficiency gave some very interesting results. Kulik [21] analyzed 97 studies and found that the difference between the traditional and the E-teaching is minimal. Most meta-analyses from that period support the conclusions of the Kulik's study (see for example [22], [34]), with exception of the Flether's study [14], which showed higher efficiency of modern tutoring systems in comparison with the traditional teaching.

Learning efficiency, compared with traditional teaching, grows in the following order: web-based teaching, hypermedia-supported teaching, teaching with assistance of interactive multi- and hypermedia, intelligent tutoring systems (ITS), and it is highest with modern ITS [34], [22], [14].

Research of individual differences and styles of learning gives an answer to the question why some students are more successful than others. Apart from learning habits and styles of learning, one of the areas that needs to be evaluated is whether there is a need to create different teaching E-materials individually adapted for students, and if so - under which criteria. In that area of research, Zufic and Kalpic arrived to the two conclusions: 1) the efficiency of learning grows if teaching materials are created by using specific text and background colors[3] [37]; and 2) the efficiency of e-learning grows if students use adapted teaching materials created based on the foremost factor of intelligence of an individual student [38].

Much research has been performed in the area of memory, efficient learning and e-learning. For example, Svegar and Domijan [29] evaluated effects of serial position within visible working memory. Henson [16] worked on theory of chain effects, order theory and theory of unit positioning. Brown *et al.* worked on a theory of a model for temporal coding position, or the so-called OSCAR model [6], [5]. Research was performed also on discovery of a mode of information coding [8], [6], [5] as well as on organization of material in long-term memorizing [3], [30], [24], [28] and these projects approach the problems described in this study. Forgetting is the process opposite from efficient memorizing. Ebbinghaus mentioned in [27] that forgetting is affected by the process of weakening of the memory trail, as well as that forgetting is a consequence of interferences, e.g. destruction of the trail due to the presence of later information, which interfere with retention of target information[4]. Ericsson and Kintsch [12] highlight connection between working and longterm memory, and the role of longterm memory in comprehension. These studies, as well as studies using tracing eye movements, support this theory [13], [20]. Cowan [9] established a model of working memory according to which working memroy represents a complex construct that includes all information available during performance of a task. The model includes elements of memory that are within the focus of attention, elements that are outside of the attention focus by temporarily activated, and the inactive elements of longterm memory. Was and Woltz [33], in

[1] *Mastery learning* - teaching with examinations, similar to the traditional teaching with a difference that students continuously write tests, and after receiving the feedback information follow corrective procedures and parallel tests.

[2] *Tutoring systems* - students learn with a personal tutor, e.g. one teacher-tutor works with one to three students. This type of teaching is accompanied by occasional tests, corrective procedures and parallel tests similar to the teaching and testing learning system.

[3] This conclusion was supported by Istrate's recommendations [19].

[4] The theory was confired by Baddeley [2].

studies using structural modelling, suggest that high correlation between measure of working memory with comprehension is partially mediated by increased availability of information stored in the longterm memory.

The next factor relevant in the mode of the knowledge acquisition and E-knowledge is reading. Reading includes processes that direct eye movements from word to word, processes at the level of a word that include decoding visual pattern of words and recollection of word meaning from memory, as well as processes at the level of text that include connecting semantic, syntax and referential relationship between successive words, phrases and sentences in the text [10]. Students who have poorer reading skills often employ reading strategies that better readers do not use. This statement contributes to those theories that emphasize importance of compensation strategies in overcoming limits of the working memory range [31], [32].

Nearly all researchers agree that control of eye movements does not play a significant role in explanation of individual differences in reading abilities [26]. Oculomotor factors definitely influence eye movements, primarily in terms of the place where the eye will stop; however, lexic factors and immediate cognitive processes have a decisive role, particularly in determination of the moment in which eyes will move, or how long they will stay on a particular word [26].

The factors that are also important for learning efficiency are attention and the existing knowledge. It is necessary to focus attention on relevant information and inhibit irrelevant information [1], [11], [35]. Knowledge within a particular domain (vocabulary) enables reader to find meaning in a chain of word combinations, and to choose between different meanings individual words might have [17].

Ichikawa *et al.* [18] performed a small experiment in design of the screen for E-teaching materials. The screen was divided into 9 squares, three lines and three rows. The best results were obtained in the upper left, upper middle and middle-middle squares, while poorer results were obtained in lower left and lower middles squares; the worst results were obtain in lower right square of the screen. Istrate [19], in recommendations for design of teaching materials, mentions that contents that are of highest importance should be position in the upper left portion of the screen. However, the experiments of Ichikawa and colleagues [18], which is similar to the study presented here, was limited due to their focus on learning of pictorial contents, imprecise division of the screen and small number of subjects (only nine).

Therefore, the goal of the enclosed study was to evaluate if there is a position of the text on the screen that will enable faster perception and/or better memorization, with a goal of a more efficient e-learning of students.

2. Methodology

Three groups participated in the experiment. First and second group, A and B, respectively, consisted of 7 female students. Third, group C, consisted of 35 participants (32 female and 3 male students). Each participant was a member of only one group. All participants were first year students of the teaching program at the University of Juraj Dobrila in Pula, 19.5-20.5 years of age. None of the participants had uncorrected visual problems (some wore glasses or contact lenses), and all were right-handed. The grade point average in high school for all three groups did not differ significantly, as well as other parameters (general education, economic status), indicating that the relevant characteristics of students in groups A and B were equalized with those in the group C.

The participants were instructed that they can leave the experiment without any penalty, but they all remained in the experiment until its conclusion. Participation in the experiment was awarded by additional points, which counted towards the final marks for the subject "Basics of text and picture design."

The study was performed using 17" monitors with 1024x768 pixels resolution. The screen was virtually divided into four columns and six rows. This division was chosen to accommodate the material used in teaching. The web-based teaching materials typically use the far-left column for content listing and navigation. Two middle columns contain teaching materials, while the far-right column is empty because designers attempt to create teaching material that would fit the screen without a need for the left-to-right scrolling, which would be inevitable if the monitor is smaller of the dimensions of the designed page[5]. In some cases, the last column is used for advertisements or sponsors' messages. The first row is typically used for navigation through the web page, teaching materials are situation between second and fifth rows, while the sixth row is used either for navigation, sponsors' messages or is left empty. These parameters are used also based on evaluation of the educational web pages from a large number of different institutions, and some characteristic representatives are mentioned in Table 1.

Institution /web site	**Screen width**	**Col-umns**	**Column contents**	**Rows**	**Row contents**	**Font type and size**	**Text alignmen t**	**Web address**
CARNet	100%	4	1 Navigation 2 Empty 3 Educational materials 4 Empty	6	1 Navigation 2-6 Educational materials	Verdana 9	Justified	www.carnet.hr
Latitudeu	650 px	4	1 Navigation 2-4 Educational materials	5	1 Navigation 2-5 Educational materials	Sans Serif 8	Left	www.latitudecg.com
Roda	Max 1000 px	5	1, 2 Navigation 3, 4 Educational materials 5 Advertisements	6	1 Advertisements 2-6 Educational materials	Verdana 11	Justified	www.roda.hr
Ahyco	620 px	5	1 Navigation 2-5 Educational materials	6	1 Navigation 2-6 Educational materials	Times New Roman 10	Justified	http://ahyco.ffri.hr

Table 1. Examples of parameters used for educational web pages of different institutions.

Each column had width of 248 pixels. Left from the first, and right from the fourth column there was an additional space with width of 16 pixels. Each row's height was 124 pixels, and above the first and below the sixth row there was an additional space with height of 12 pixels. The screen had no lines to make the division visible. Scheme 1 shows the screen division according to the described positions. The inner line marks the edge of the texts, while the outer line represents the outer edge of the screen.

A1	B1	C1	D1
A2	B2	C2	D2
A3	B3	C3	D3
A4	B4	C4	D4
A5	B5	C5	D5
A6	B6	C6	D6

Scheme 1. Screen division and position of the texts.

The screen was divided into a total of 24 units, marked from A1 to D6. Twenty eight texts were prepared for the experiment (4 trials and 24 experimental), thematically significantly

[5] It is necessary to create such teaching materials that will be easy to use (Ichikawa 2006), which means that the entire teaching material needs to fit into the screen – without scrolling [19].

different, but identical in size (21 words, 130 letters not counting spaces). The texts were meaningful, logical, easily memorized, and belonged to different areas of life. Taking into account a possibility of the knowledge transfer, the authors chose neutral texts, as much as possible, that belong to a category of general knowledge curiosities, and for which previous knowledge would not interfere with the acquisition of the new knowledge.

For example (Croatian version):

> Gotovo svaki madrac na tržištu želi nas namamiti u horizontalu uz kvazimedicinska obećanja, a najtvrđi su gotovo uvijek kvalificirani kao ortopedski.
>
> Administracija većeg američkog grada istjerala je pušenje sa svih javnih površina i natjerala restorane da za svako jelo navedu kalorijsku vrijednost.
>
> Žene koje jedu nemasne namirnice obogaćene biljnim vlaknima manje su podložne obolijevanju od smrtonosnog karcinoma jajnika i rizika od jakih bolesti.

Texts were written in Times New Roman, size 11, left aligned, and prepared in HTML (Hyper Text Markup Language) Eyes of the reader were 60-80 cm away from the screen, parallel with the monitor area, at the level of the upper edge of the monitor.

Since the purpose of the study was to establish whether text position affects the efficiency of memorization, it was first necessary to determine the average percentage of an individual text that will be used for the main experiment. Therefore, two trial experiments were performed before the main experiment.

2.1. The first trial experiment - evaluation of the ease of text memorization

Although the texts had an identical number of characters, words and spaces, that did not necessarily mean that they are equally easy to memorize. Therefore, it was first necessary to establish how much the texts differ from each other based on the ease of memorization. The ponders (difficulty coefficients) were introduced. The ponder is inversely correlated to the average value of memorized signs in the text. The easier the text (larger number of memorized signs), the smaller the ponder. If the text is more difficult (less memorized signs), the ponder is greater. Ponders rho (ρ_i) will mathematically equalize texts based on how easy/difficult they are to memorized. The ponders were calculated based on the formula:

$$\rho_i = \frac{n_{iuk}}{\overline{X}_i} \qquad \text{Equation [1]}$$

in which:

- ρ_i represents the ponder for the text i
- n_{iuk} represents the total number of characters in the text i
- $\overline{X}_i$ represents the average number of memorized characters in the text i

Group A read a single text in the middle of the screen for 60 seconds after which they had 120 seconds, using pencil and paper, to solve simple mathematical calculations (additions or subtractions up to 10) in order to prevent the texts they learned to be repeated and stored in the short-term memory. Focused attention, inhibition of the irrelevant information, and good method of information coding were required of students in order to recall the memory. Previously published research has shown that an information can be kept in the short-term memory, without repetition, for approximately two seconds [2]. After these tasks, they had to write the text they were supposed to memorize using computers. Hundred and twenty seconds were sufficient for writing of the text. No student had complaints related to the shortness of the time for writing, suggesting that the potential variable of different knowledge of work/writing on a computer was not relevant, e.g. had no effect on the construct of the dependent variable (text memorization). After that followed a break of 3 minutes, which students used for a relaxing discussion not related to the test contents, followed by repetition of the task. On the first day, the participants evaluated 9 texts, for a total of 69 minutes (9 x (1 min for reading + 2 min for calculations + 2 min for writing) + 8 x 3 min for breaks). On the second day, they evaluated the following nine texts in the same amount of time, while on the third day they evaluated the remaining 10 texts (in a total of 77 minutes).

The result was calculated by counting all the characters the student wrote correctly. If a word was written correctly only partially (for example, wrong declination or time), only the correctly written characters were counted. Punctuation signs were accepted, but similar words - synonyms, or general meaning of the text were not accepted. In the event that an individual text caused a significant outlier for an individual student, compared to the results obtained in other students, that result was not taken into account during calculation of the average results for that text. Five out of 210 values (30 texts x 7 subjects) were rejected due to such constraints.

2.2. Second trial experiment - design of the testing material on the screen

Group B was used to determine how many texts and with which percentage of success can efficiently memorize in order to avoid the "ceiling and floor" effects (so that the tests were neither too difficult, nor too easy, e.g. to avoid reduction of variability), and the optimal time for reading and writing. It was determined that students had difficulty memorizing more than 4 texts - therefore, the screen contained only four texts.

The limit of four texts was used because the students wrote over 50% of the each text when they were presented with two, three or four texts. When presented with five texts, only 30-35% of each text was memorized, with further decrease with addition of more texts. The same criterion (50% success rate) in research in unit recall was used and recommended by Jacobs (1887 – according [2]).

Each column contained one text, while four to six rows were filled with the text in each position. Additional limits for texts were that two continuous rows cannot be empty, the distance between texts must be a minimum of 3 units (horizontally, vertically or in the form of letter L - similar to the movement of the horse in chess), and that on a single diagonal (any diagonal in the table) cannot contain more than two texts.

The positions and order of appearance of the texts can be determined using a computer program. This problem is similar to the problem of movement of the horse in chess, with a limitation that it can stop at each field only once. This type of problems is resolved using the theory of graphs[7] and the so-called Hamilton's[8] cycle. Although there are many algorithms for resolution of the Hamilton's cycle[9], a sufficiently efficient algorithm capable of resolving the problem posed by the theory is currently unavailable. However, the problem posed by the experiment is not particularly difficult, and could be resolved by the following algorithm:

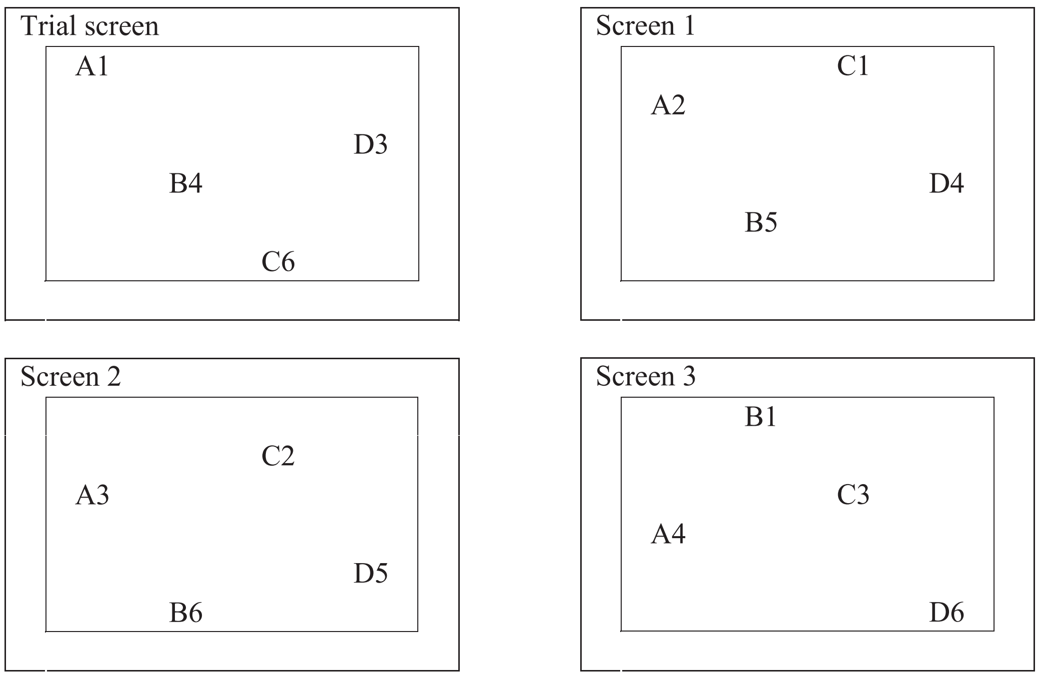
[7] The theory of graphs was originally developed by the Swiss mathematician Leonhard Euler (1707-83)

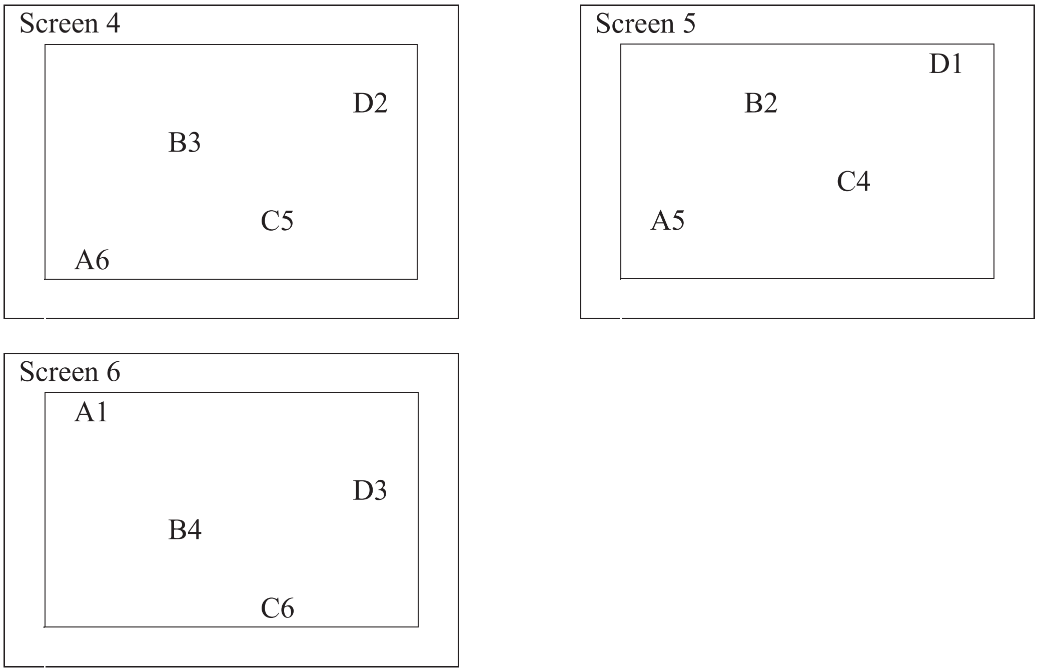
[8] The first mathematician who studied passing through the top of all the graphs was the Irish mathematician William R. Hamilton (1805-1865)

[9] The Hamilton's cycle is the circular path in the graph that passes through the top of each graph only once

```
take position to the cell A1 and mark it;
      move to the right by 1 field (or more if the
             cell is in the same row as the
             previously taken cell);

      if the assigned cell is within the field and
             not in the same row as the previously
             marked cell, mark the current
             position;
      otherwise, count from the top of the column
             and mark the cell if the above
             mentioned condition is fulfilled;

      continue until column D is resolved;

take position at A2;

      repeat the above algorithm;

repeat until all positions in all the fields are marked;
```

Since there are multiple possible solutions, and the authors did not find a pattern according to which to position the text in the existing literature, the text was positioned as shown in the scheme 2, which was developed by modification of the above-mentioned algorithm. The positions of the texts for the trial and for the sixth screen were identical, the text was different.





Scheme 2. Positioning of the texts on the screens

It was relevant to have the texts sufficiently distant from each other, and that their contents are sufficiently different in order to prevent associative or reproductive interference [15], which would affect the final results.

2.3. The main experiment

Group C was the main experimental group. The students read four texts from the screen (according to the positions determined through the experiment performed with the Group B). The validity construct of the experiment was not jeopardized by simultaneous presentation of four texts on a single screen. It is known that the differences in memorization of the presented sentences does not have to be solely due to the differences in position, but could also be a result of differences in preferences of the experimental subject that determines the amount of attention given to a certain position/sentence compared to another. However, the goal of the experiment was to establish whether there is a connection between the screen position of the text and efficacy of learning. It is possible that a certain position is associated with better/poorer “attention,” thus causing better/poorer efficacy of learning/memorization in that position.

The reading was limited to 240 seconds. The students then turned off the monitors and spent the following 150 seconds solving simple mathematical calculations in a manner similar to the Group A. The memorized text was then written using computers in seven minutes of the total time allotted, followed by a 3-minute break. The procedure was repeated two more times using different texts in different positions. Total length of the experiment on the first day was 46.5 minutes [3 x (4 min for reading + 2.5 min for simple calculation + 7 min for writing) + (2 x 3 min breaks)]. The first reading (one screen with four texts) on the first day was taken as a trial, the results were recorded, but were not included in the data analyses. The experiment continued on day two with another 3 screens (12 texts in total) in the same time of 46.5 minutes. On the third day, the students spent 13.5 minutes in the experiment (one screen with four texts). No method or memorization strategy was suggested to the students.

In total, the participants went through the 4 trial texts (1 screen) and 24 experimental texts (six screens). The texts were always in a different position. The students were instructed to write the texts identical or as close to the original texts as possible, including punctuation. The order of writing the texts was decided by individual students. The results took into consideration only correctly written letters and punctuation signs.

3. Results

The results obtained in the Group A, by which we evaluated the average values and standard deviations of the memorization of the texts when showing a single text on the screen, are shown in Table 1. Apart from these values, the values for ponders calculated by the equation [1] are also shown. The ponders were used in evaluation of the Group C results in the main experiment.

Text title	$\overline{X}$	σ	ponder	Text title	$\overline{X}$	σ	ponder	Text title	$\overline{X}$	σ	ponder
A1	115,6	14,3	1,125	B3	110,7	10,8	1,175	C5	92,1	7,8	1,411
A2	112,2	16,4	1,159	B4	103,6	21,1	1,255	C6	100,0	26,0	1,300
A3	127,3	4,6	1,021	B5	114,5	10,7	1,135	D1	106,7	17,7	1,218
A4	108,7	29,5	1,196	B6	110,0	7,1	1,182	D2	124,0	9,5	1,048
A5	129,3	1,5	1,006	C1	111,7	11,9	1,164	D3	128,2	3,5	1,014
A6	126,7	3,8	1,034	C2	115,0	8,8	1,130	D4	122,3	6,6	1,063
B1	98,3	27,4	1,322	C3	121,7	12,7	1,068	D5	122,3	9,4	1,063
B2	121,8	11,1	1,068	C4	102,4	20,1	1,270	D6	124,2	5,1	1,047

Table 1. Average values ($\overline{X}$), standard deviations (σ) of the Group A results with the associated ponders

The results of the main experiment with the Group C are shown in Table 2. Apart from the average value for the each position, we also calculated the ponderated values and standard deviation of the ponderated values, σ_p. The ponderated average values $\overline{X}_p$ were calculated by multiplying the average values achieved by the Group C with the ponders calculated for the Group A, as previously shown in Table 1, and according to the equation [2]. This approach enabled comparison of the results obtained through different texts, since the effect of the easier or more difficult text for memorizing was thus removed, leaving only the effect of the text's position.

$$\overline{X_{ip}} = \rho_i \cdot \overline{X_i} \qquad \text{Equation [2]}$$

where:

$\overline{X}_{ip}$ represents pondered average values of the memorized text i

$\overline{X}_i$ represents the average value of the memorized text i

ρ_i represents the ponder for the text i

i represents text number (between 1 and 24).

The average values of the memorized texts on all positions after pondering is $\overline{X}_p$=79.25 with statistical deviation of σ_p =40.65. The t-test values were calculated between the average values of all position and an individual position. The positions and their associated values that are statistically different at the level of probability $p<0.05$ are shaded and marked with bold font. T-test could be used because the distribution of the values did not differ significantly from the normal distribution according to the Kologorov-Smirnov's test.

Text position	$\overline{X}_p$	σ_p	**t-test**	**P**	**% of the total average**	**Text position**	$\overline{X}_p$	σ_p	**t-test**	**P**	**% of the total average**
A1	75,2	41,7	0,462	0,644	94,8	B1	82,9	42,7	0,431	0,6670	104,6
A2	**96,8**	**31,3**	**2,127**	**0,034**	**122,1**	B2	95,2	29,8	1,903	0,0575	120,1
A3	64,3	35,2	1,804	0,072	81,1	**B3**	**106,0**	**31,6**	**3,179**	**0,0015**	**133,8**
A4	**54,7**	**35,9**	**2,900**	**0,004**	**69,0**	B4	91,1	47,0	1,331	0,1837	115,0
A5	**99,8**	**29,9**	**2,451**	**0,015**	**125,9**	**B5**	**59,5**	**54,9**	**2,328**	**0,0203**	**75,1**
A6	93,8	28,5	1,723	0,085	118,4	**B6**	**43,0**	**47,8**	**4,237**	**0,0000**	**54,3**
C1	72,6	37,5	0,790	0,429	91,6	D1	70,2	35,2	1,067	0,286	88,6
C2	73,5	46,4	0,685	0,493	92,7	**D2**	**96,2**	**30,3**	**2,021**	**0,044**	**121,4**
C3	95,0	25,6	1,871	0,062	119,8	D3	90,9	25,7	1,333	0,183	114,7
C4	**51,5**	**42,8**	**3,259**	**0,001**	**65,0**	D4	79,2	37,5	0,007	0,994	99,9
C5	92,2	51,2	1,506	0,133	116,3	**D5**	**59,0**	**42,4**	**2,429**	**0,015**	**74,4**
C6	67,2	48,9	1,347	0,178	84,8	D6	74,4	35,0	0,577	0,564	93,9

Table 2. Results of the Group C according to the text position

In table 2, $\overline{X}_p$ is the pondered arithmetic mean, and σ_p is standard deviation of pondered arithmetic mean. Several students could not remember any portion of the text in certain positions. The number of unwritten texts according to the position is shown in Table 3. Mark "0" means that the text in that position was written by all students.

Text position	**Number of unwritten texts**	**Text position**	**Number of unwritten texts**	**Text position**	**Number of unwritten texts**	**Text position**	**Number of unwritten texts**	**Total by rows**
A1	0	B1	2	C1	2	D1	0	4
A2	0	B2	0	C2	3	D2	0	3
A3	1	B3	1	C3	0	D3	0	2
A4	3	B4	6	C4	4	D4	2	15
A5	1	B5	9	C5	3	D5	6	19
A6	1	B6	10	C6	3	D6	0	14
Total:	A column: 6	B column: 28		C column: 15		D column: 8		57

Table 3. Number of unwritten texts according to the position.

The average values by column were similar, and was 80.3 for column A; 79.3 for column B; 75.4 for column C and 78.0 for column D, with standard deviation between 37 and 47. The differences were not statistically significant by the t-test.

The values according to the position by rows are shown in Table 4, while Table 5 presents the achieved results by dividing the screen into four large blocks, upper left (cells A1-B3); lower left (A4-B6); upper right (C1-D3) and lower right (C4-D6).

Text position by rows	$\overline{X}_p$	σ_p	t	P
1	75,2	39,0	0,889	0,374
2	**90,0**	**36,2**	**2,437**	**0,015**
3	**88,7**	**33,4**	**2,145**	**0,032**
4	**68,8**	**43,5**	**2,280**	**0,023**
5	77,3	48,7	0,429	0,668
6	**69,6**	**44,1**	**2,082**	**0,038**

Table 4. Achieved results by rows.

Position of the text by blocks	$\overline{X}_p$	σ_p	t	P
A1-B3	**86,7**	**37,8**	**1,989**	**0,047**
A4-B6	73,3	46,7	1,494	0,136
C1-D3	83,0	35,8	0,992	0,322
C4-D6	**70,6**	**44,5**	**2,209**	**0,028**

Table 5. Achieved results based on the position blocks.

Because each screen contained four texts, and a student could choose which text to write in which order, the direction of writing of the texts was also evaluated. Two basic divisions were made: horizontal (order of columns in which the text was positioned) and vertical direction (order of rows in which the text was positioned. The horizontal direction was divided into five parts: LD - from left border of the screen towards the right border (A, B, C, D); DL - from right to left (D, C, B, A); UV - from the interior towards the exterior columns (for example B, C, A, D or C, B, D, A); VU - from the exterior to the interior columns (for example A, D, B, C), and the rest (any combination that is not mentioned). The vertical direction was also divided into five parts: GD - from the upper edge of the screen to the lower edge (when the rows are ascending, for example 2, 3, 4, 6); DG - from the lower to the upper rows (when rows are descending, for example 6, 4, 2, 1); UV - from the interior to the exterior rows (for example 2, 3, 1, 5); VU - from the exterior to the interior rows (for example 5, 1, 4, 2) and the rest.

By horizontal direction, over 70% of the texts were in the group "the rest," approximately 20% were writing texts from the exterior columns to the interior columns, while the remaining <10% was equally divided between the other groups. The average percentage of memorizing was not statistically significantly different.

By vertical direction, approximately 75% of the texts were in the group "the rest," approximately 20% wrote texts from upper to the lower rows, while the remaining approximately 5% was equally divided among the other groups. The average memorizing did not significantly differ.

Regardless of the order in which the texts were written, it is significant to notice that the earliest texts had the best results, while the text written the last had the worst results.

The strategies students used during learning were different. Some students read the text several times (2-4 times), others memorized central words while the rest of the text was either superficially memorized or there was no statistically significant difference (between the central word and the rest of the text?). It was noted that the beginning and the end of the text was typically better memorized, while the middle portion contained many lost words. This result conforms with the memorization curve in dependence with the learning unit position [36].

4. Discussion

From the Table 2, it is evident that texts position at A2 (22.1%); A5 (25.9%),; B3 (33.8%) and D2 (21.4%) was associated with better memorization, while positions A4 (31%); B5 (24.9%); B6 (45.7%); C4 (35%) and D5 (25.6%) were worse than average (percentage in the brackets represents the average percent). The best results were achieved in position B3 with 133.8% compared to the average, while the worst results were at 54.3% of the average at the position B6. Comparing the achieved results by row, better than average results were obtained in the second and third rows, and worse in the fourth and sixth rows. The achieved results by blocks were better than average in the upper left quadrant (A1-B3), and poorer in the lower left quadrant (A4-B6). The reason for poorer results in the lower rows is also in the fact that these positions also had the most unwritten texts (see Table 3). The results by rows show that text positioned in the second and third rows are memorized better, while those in rows four and six were memorized worse than the average. If the results are analyzed by the block position, it is evident that texts positioned in the upper left were memorized better, while those in the lower right were memorized poorer than the average. Analyses by columns did not show statistically significant difference.

Considering the fact that writing and reading in Europe and the Americas are from left to right, and from up to down, it was expected - and experimentally shown - that texts in the positions of the upper left block were better memorized. This experiment confirmed this reading orientation. All students started reading text position in column A or in one of the first two rows. Furthermore, better results were obtained for texts positioned in the second and third rows, while the last three rows had worse results.

Comparison of our results with those achieved by Ichikawa and colleagues, as well as with the recommendation by Istrate, suggests similar results for textual teaching materials. Although the division of the materials was insignificantly different (they divided screen into 9, while we divided it into 24 units), the best results were achieved in the upper left quadrant (blocks A1-B3, or positions A2 and B3), and the worst in the lower right, in our study in the lower left (group A4-B6, rows 4 and 6).

Concerning the order by which the students wrote the texts, it is not possible to draw a conclusion since the students mostly wrote the texts according to a changeable pattern/order.

Standard deviation of the achieved results after pondering was between 19.6 and 29.8. We expected somewhat lower values, and the reasons for higher values are in the order of writing of the texts in individual series (nearly without exception, first written text achieved the best results, second somewhat poorer, third even worse, and the fourth the worst).

Some results were unexpected and different from those achieved in other published studies. For example, high values achieved in A5 (119.6%), A6 (113.3%) and C5 (121.1%), and relatively low values achieved in A3 (82.6%), A4 (81.1%) and B4 (68.2%). One possible reason for these results is in the moment at which the texts appeared on the screen. From the scheme 2 it is obvious that (screen 5) the position A5 was positioned most to the left and it appears that the students started reading it, paid most attention to it and memorized most of the text in that position. The same could be said for A6 (screen 4). However, some results cannot be explained by this factor (for example A3, A4 and C5). One of the possible reasons could be the calculated ponder of the easiness of memorization of the texts (high for C5 and A4) in certain positions. During the process of determination of the ponders, group of only seven students was used, so it is possible that ponders for certain positions are not equally valid (it is sufficient that one or two persons achieve poorer results for a certain text, and the ponder would change). Another reason could be also in the fact that this is one of the first experiments in this research area that gave some practical recommendations, and a theory (e.g. a model) that would confirm or reject these results is yet to be discovered.

Although the experiment in question had the primary focus of development of a paradigm for a study, some practical recommendations can be given to assist teachers and designers of the teaching E-materials in creation of more efficient contents. The basic suggestions stemming from this study are:

- Text that should be remembered should be positioned in one and no more than two columns.
- The most important part of the text should be positioned in the upper left quarter of the screen.
- Text that is less relevant should be positioned in the lower rows.

In this discussion and conclusions certain limiting factors should be taken into account:

a) The screen contained only four texts, while the remaining 20 positions were empty. That contributed to some unexpected results.
b) Results could be generalized for the sample of younger students. Although the sample predominantly contained female students, gender most likely is not a relevant factor it this mode of learning.
c) Although the sample was not numerically large, similar type experiments typically are not performed on larger samples.

In future research, it is important to take into account these limiting factors, and suggestions for future research would be to evaluate type and size of the font used in the text, the amount of text on the screen, the ratio between content and empty space on the screen and similar elements.

5. Conclusion

The study determining the effect of the position of the teaching material on the monitor on learning efficacy mostly confirmed studies by other researchers. We have shown that certain position on the screen (upper left) correlate with higher learning efficiency, while others (lower left) in which learning efficiency was lower than average. Furthermore, learning was more efficient with texts in the upper rows compared to those in the lower rows. The recommended finer division shows these positions even more precisely. e-learning material designers should use results of this and other studies to achieve an increase in learning efficiency. Thus, more important teaching materials should be positioned in the upper left rows, and less important materials in lower rows. However, further research related to the position of teaching materials needs to be performed since more and more teaching materials are presented in some electronic form.

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