

Effectiveness of Text Visualization as a Learning Facility (A Review)

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Abstract—visual presentation of the text is a recognized technique can be used as an auxiliary tool to assist the users being fixated on the important parts of the text to be learnt; in order to attract the users' attention on the specific portion of the text content some basis and foundations of are mostly in common among the visualization techniques that are: psychological, multimedia, and typographic cueing and techniques (visual effects). This paper intends to provide a concise review on concept of 'text visualization', its current status and strengths and limitations of some different approaches adopted based on design and implementation of an optimized text visualization tool. The study has focused mainly on conducting a descriptive research in order to analyze differentiations and methods of text visualization.

Index Terms—Text visualization, Memorization, Cognitive load, (Visual) Spatial ability and Typographic effects

1 INTRODUCTION

Based on immense growth of textual materials due to the rapid and often exponential scientific advancements, more value has been accrued to and more consideration has been given to the process of acquiring subject matter conceptual matrix through text. On the other hand, young students' learning process is greatly challenged when reading, remembering and perceiving the information from the electronic text contents. So in order to surmount this challenge, text visualization can be used as a recognized approach to accelerate and optimize learning practices

TEXT VISUALIZATION: is "a tool or method for interpreting image data fed into a computer and for generating images from complex Multi-dimensional data sets" [1]. Since texts contain information therefore visualization of textual materials could be termed as a form of information whereby it becomes often advisable to have it visually represented. Social sciences approaches will be applied as a significant issue for evaluating the different methods of text

visualization. This is due to the integration of the text visualization with the empirical researches related to the subjects as: human computer interaction (HCI), perceptual psychology, and cognitive elements

2 EFFECTIVENESS OF TEXT VISUALIZATION AS A COMPUTER ASSISTED TOOL FOR LEARNING

Numerous researches have been conducted in order to evaluate the effectiveness of text visualization on improving the students' learning and their educational achievements, especially in lower level of study. According to [2], using the different techniques of text visualization that use the computer technology is a method to create a graphical representation of the text, and will be beneficial to understand the large and complex text. Therefore the information conveyed by the visualization approaches is easier to recall and memorize [3]. Besides, information visualization will be effective in changing the learner's attitude and improving their skills in using technology in the field of learning and education [4]. Another study [5] indicated that the learners would be more interested in learning and perceiving the concepts by interactively usage of information visualization tools. Considering the outcomes of the above studies, the general effectiveness of text visualization can be clustered into: Reader's comprehension, reader's concentration on the content, understanding of text structure, attractive

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learning experience and improvement of learner's attitude and capabilities in using technologies in the field of learning

3 THEORETICAL BACKGROUND

Through the careful and through analysis of the relevant text visualization researches, it has been learnt that the theoretical background for the techniques offered by different papers are mostly related to the major branches of psychological, human computer interaction (HCI) and text structure concepts; in this section the theories consistent to the reviewed models and techniques of text visualization will be defined.

3.1 Dual coding theory (DCT): cognition consists of the two major subsystems functioning, first, a verbal system that is dealing with language, second, an imagery system specifically contend with non-verbal objects and events. This theory denotes that the both mentioned systems are generally involved even in verbal occurrences; As the result cognition will be the diverse level of the two systems' intervention in a cognitive phenomenon based on their degree to which they have been developed [6], [7]

3.2 Gestalt theory of visual perception: the basic notion of gestalt theory is arguing about the structure, arrangement or an overview of some individual things that have greater specific characteristics in a unified form rather than sum of its single elements. This theory is arguing about profound influences of structural changes like spacing and timing on the meaning of an informative content. For instance when a person reading a sentence acquires each word and its meaning completely, rather than looking the individual letters. Gestalt theory can be applied in varied fields like: Human computer interaction (HCI), visual communication, and visual design. The gestalt laws of perception are highly applicable for visual designing because they are explaining the inclination of human to "group" and "unified" things, and technically defining the human perception based on the scientific rules. [8]

3.3 Cognitive load theory (CLT): Cognitive load is a multifaceted structure denotes the load that does a specific task carrying out by human cognitive system [9]; Cognitive load theory is describing the

human cognitive architecture and the relation between the long-term memory and working memory. CLT is discussing about the enhancement of an efficient instructional methods using the human limited cognitive processing capacity to ignite the learner's capability to appeal for the previously learnt knowledge into the new status quo. Referring to a research led by F. Pass & J.E Tuovinen [9] cognitive architecture contains a limited working memory sections that are communicating with the long-term memory and responsible for visual/spatial (non-verbal) and auditory/ verbal processing.

The importance of this theory is related to the optimization of the working memory, for this reason in the designing process of an instructional material, it is critical to consider this issue that how this material is interacting with the cognitive system (working memory and long term memory). [9]

3.4 Multimedia modeling and the cognitive theory of multimedia learning: multimedia can be defined as presentation of a material that integrates spoken and visual (picture) elements. [6]

as the basic and fundamental objective of information visualization is to enhance the knowledge acquisition, so the cognitive theory of multimedia can buttress this goal in the way that, pictorial information and verbal information are going to be processed in visual and verbal channels separately, while verbal information which is represented in a visual format will be processed in both channels, on the other hand the capacity of the both channels are limited, so the information to be processed should be in a format that the learner has to use both channels for information processing to avert the cognitive overload in the pictorial and verbal channels. [10]

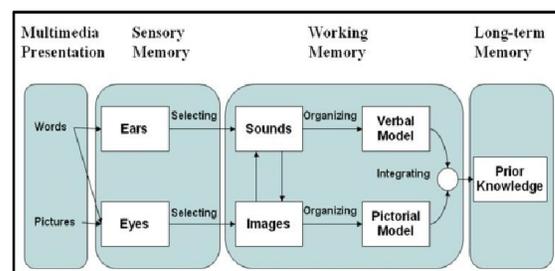


Fig. 1. Cognitive theory of multimedia learning. [30]

3.5 Color coding approach: color coding approach is a graphical method that employs color for analyzing and visualizing the hidden resonance of the text. According to H.Liu&T.Selker [11] colors can be effective for this purpose due to some of the specific characteristics of the colors as: first, being visually separate and this attribute make them capable of encoding the different word classes in a sentence or a text content additionally the colors are innately evocative, hence the color coding approach force the usage of color meaning and expression based on a criteria(cultural meaning of the colors, psychological expression) for the meaning of the colors. [12]

3.6 Human Computer Interaction (HCI) concepts for optimized visualization: some of the useful prospects of visualization, especially text visualization, are derived from the advantages of human computer interaction (HCI) aspects, the main objectives of the HCI are :1) matching the features of the virtual world to the user characteristics, 2)providing an effective tool that the user can perceive the needed knowledge with minimal effort (perceptual characteristic of HCI), 3) the perceptual assets of the virtual world provided by HCI is highly influential on the cognitive load and cognitive demand , for this reason the visualized data offered by the HCI used for solving the problems can abate the processing and memory load significantly [10]

3.7 Human brain (left/right) functionality: Refer to the anatomy of the human brain, the left side of this organ is in charge of the logical duties like: words, numbers and thinking tasks, simultaneously the right side is responsible for identifying colors, imagination, voice, music and feelings.

according to the analysis of the human brain functional structure provided by E. Frangenheim[13] left brain is responsible for analytical tasks, investigating for detailed data, doing the logical and definitional jobs, and it is reliant on literal meaning; in contrast, the right side more dependent on images, colors and vision than words, moreover, right brain's functions are more literal rather than being logical, and innately holistic.

4 RESEARCH TRENDS AND MODELS:

Through this section the most recent and effective researches and papers related to text visualization and their applied visualization methods have been extensively analyzed which are briefly represented as following:

According to S.Hee Jin [14], two main issues hindering the process of learning, first, failure of the readers in understanding of the text structure, and the second issue is failing to concentrate on the learning content, he took these issues into consideration and conducted a research to scrutinize the efficiency of a proposed visual design guidelines that are mainly emphasis on the enhancement of the text structure and attracting the reader's attention, on the quality of readers learning. In this research 141 university students were randomly assigned to answer the questions which have been visualized based on the guidelines; Experiment result indicated that the comprehension level for the groups assigned to do the test based on the text with either of structure design and selective attention design is significantly higher than the comprehension level for the group that received the text with no visual design guidelines.

The outcome of this research is a proposed model application for text visualization which implemented on the basis of Gestalt theory of visual perception, Cognitive load theory (CLT) and Human Computer Interaction (HCI) concepts for optimized visualization; this model is applying the four major guidelines of text visualization for better understanding and optimized content learning.

Refer to the visual design guidelines' methodology, four approaches offered as the most effective methods of visualization that the first two of them are aiming for content structure understanding, and the other two assist the reader to concentrate on the text using the typographic effects that is the t designing and arranging the type in the page, in order to render a text into a pleasant, easy to read and attractive format. [15], [14] the guidelines represented as below:

- Visualize the relationship between the paragraph and pages
- Visualize hierarchical structure between pages and present the selected Page in overall hierarchical structure context
- Visualize the keywords meaning or key phrases with motion
- Present keywords of phrases in order

Based on the definition of spatial ability which discusses about the skills related to representing, transforming, generating and recalling the metaphorical, non- verbal information [16], a research by G.Korakasis [17]evaluates the impacts of the three multimedia visualization approaches collaborated with description and text represented by a multimedia application called “atomic orbital” (as the learning virtual environment) on the learning process of the 12th grade pupils (age 17-18) in the field of science. The three visualization approaches are as: (1- Visualization in interactive 3D virtual environment (I3DVE), 2-Visualization in 3d animations interface (3DAIF), 3- Visualization in 3D static illustration interface (3DSIFF)). In this experiment the number of 111 students are asked by the total of 9 questions in the format of multiple-choice, filling the blanks, and visualized inquiries; at this section the students must answer these questions while every versions of multimedia application is operating; With consideration to the spatial ability as an influential variable on the multimedia learning, the results demonstrate that perceiving and understanding of the 3D object has been performed adequately by applying the (I3DVE) approach, as the result of complete development of spatial ability between the 12th grade students.

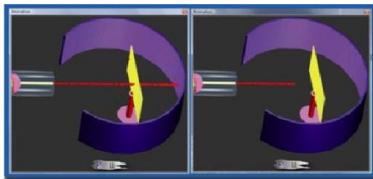


Fig. 2. Visualization in 3D animations interface (3DAIF)

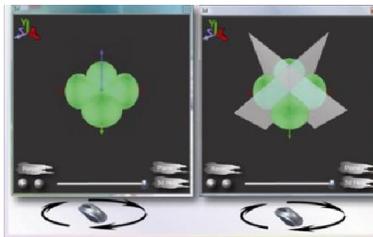


Fig. 3. Visualization in interactive 3D virtual environment (I3DVE)

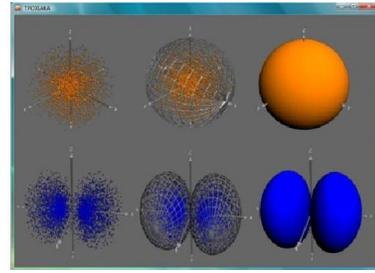


Fig. 4. Visualization in 3D static illustration interface (3DSIFF)

Analogous to the previous text visualization researches A. Hamdy and M. Elhoseiny [18] performed an experiment on the basis of the integration of the left and right human brain functionalities, hence they proposed a model of text visualization which called Mind mapping which convert the text content into a pictorial single level and multilevel Mind map, based on the definition of memorization as a process of encoding (knowledge representation), retention, retrieve, and decoding (knowledge reformation); consequently, for gaining a better outcome of memorization [19] the performance of information processing and memorization of the processed data can be done faster and better if the information are being in the form of neural cells, for this purpose by the efficient usage of 2 halves of the brain the information can be represented in the form of neural cells and visual information. One of the instances of this concept is that, people are usually remembering the other one's faces while they have problem in recalling their names.

Three different testing surveys conducted based on the MTurk Human factors to examine: A) satisfaction of the user by with the output of the system in the form of single level Mind map, B) satisfaction of the user in related to the concept amalgamation. C) To evaluate the information partitioning in the multilevel mind map generated from the view of the user without considering the pictures provided for the text. The result of these experiments is indicated the acceptable satisfaction of the users with the Hierarchical information illustration, generated by multilevel and single level Mind Map. Based on this research, M. Elhoseiny [18] offered a mind-mapping model, which receives a text as an input, and converts it to a visualized mind map. The end result mind map generated by this application will be an integrative visual and succinct product. The mind map produced by this application has two main attributes:

- Visualizing the meaning with the suitable image (by using the Google image search engine)

cognitive effort required to overcome the complicated problem will be abated. [22]

However, with consideration to the “dual channel” and “limited capacity” Assumptions of a “Cognitive Theory of Multimedia Learning” [7], [29] and the “cognitive load theory” [28] the usage of interactive 3D virtual environment and pictorial visualization generate a heavy cognitive [17]; on the other hand, it can be enumerated as another problematic issue, when learners misconstrue the design and formation of the visualization or when he/she is facing an incongruity between the visualization and his/her own conceptual depiction. [22]

Furthermore learner’s spatial ability has an effect on the degree of 3D visualization understanding [17] Recruitment of the 3d models for the learners with low spatial ability will be resulted in a cognitive overload.

The model of information visualization presented by W.Weber [12] applies the colors to visualize the different texts. Overall attributes of this approach can be in parallel to the principals of the effective visualization and color designing, whereas this approach is presenting the organized information and it categorizes pertinent information and assigning a specific color to each category. Refer to the effective design principals mentioned these factors can assist learners to better understand the relationships between items and their roles in the text [23]. Recruitment of the colors in content visualization can draw the learner’s attention in proportion to the significance and importance of information.

Instead, based on the different cognitive preferences of the learners, some color coded portions of the text may attract more attention than other parts. Besides, inadequate amalgamation of the color [23] in visualizing the information, may be resulted in generation of confusing and unattractive information [25]

Refer to the other practice of ‘information visualization’, done by E.Jones[26], the comic visualization applied as an auxiliary mean for second language learning.

Split attention effect occurs when two visual information existing simultaneously to achieve the meaning. Usage of dictionary or glossary to look up the new vocabularies’ meanings increasing the probability of split attention occurrence for beginner language learners [26]. Thus, combination of the comic visualization with the reading content is useful to help learner for reaching the meaning of the vocabularies.

Engagement and entertainment are considered as the potentials that 3D, pictorial and comic style visualization can possess.

P.chatterjee [27] defined the engagement as: “the learner’s act of investing effort and commitment to meaningful activities in anticipation of learning outcomes”

Based on the result of this experiment E.Jones[26] stated by the participants’ and the definition of engagement, using the comic integrated text can be amusing and engaging for the beginners.

In contradiction to the above potentials of comic style visualization, applying the pictorial or comic [26], [18] approaches may product the ambiguity in understanding and interpretation of the words’ meanings [24]

Furthermore the visualizations accompanying the text may seem to be confusing for the learners if they are not providing a translucent general logic [26]

6 CONCLUSION AND FURTHER DEVELOPMENT

The main objective of this study to analyze the most recent techniques and models of “text visualization” in order differentiate the varied aspects of these studies and their influential roles in the learning process of students. All of the researches and models studied in this paper have been scrutinized theoretically and technically.

The holistic finding of this study is shown that, firstly using the pictures/ visual aid in collaboration with the text; assist the learners to effectively engage with the mental activities and learning concepts. On the other hand providing the visual aid will help the learners to better understand the complex problem and reduces the cognitive effort required to overcome such problems.

The usage of the visuals enhances the learner’s capability to make connections with the textual word and its meaning. By doing so, this greatly reduces the cognitive load on the working memory (short term memory).

Besides applying the approaches of visualization on the text attract the learner’s attention to focus on the text to be learned. Additionally visualization provides an amusing experience of learning for the learner.

Above all, some limitations and constraints of the proposed models and researches reported by authors, one of the limitations is that in some on these experiments to evaluate the effectiveness of visualization method especially in 3D visualization, the age of the learners plays a crucial role in science

Education.[26],[17],[14], as another limitation of visualization reported by M. Elhoseiny[18] the proposed method of visualization is not capable of perfuming the high accuracy visualization for the large text and varied subject, hence the further studies will be needed to be developed the visualization model regard to the development of a visualization model that can be deployed to the different age groups and different learning topics. In addition enhancing the visualization system to be reliable for large text must be taken into consideration for further development of visualization systems.

Based on the extensive analysis of the reviewed researches and their attributes in this paper, it has been obtained that using the summarization before applying the typographic effects and the color effects on the text after summarizing, summarization Will decrease the size of the content and help the user to focus on the important parts of the text to be learnt. Consequently decreasing the size of the leaning text content plus to the visual effects imposed to that, will abate the cognitive load considerably and help the student to learn and memorize the text more efficiently.

For the above reason using the text extraction, note taking, lexical analysis for summarization and withdrawing the important part of the text to be learnt, in collaboration with the visualization approach (color effect, typographical text designing) can be leaded to maintain the learners ' attention on the text more effectively in realm of optimizing the students' learning ability.

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