

The Formation of Skills to Visualize by the Tools of Computer Visualization

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Abstract – The article presents the aspects of the formation skills to visualize with the use of specialized software. The authors note about the importance of visual representation of information content, which allows speeding up the perception and processing of text, data arrays, etc. Basic methods of visualization are described. The special course is described, which main aim is to form skills to visualize by the tools of computer visualization. The method for processing results of educational achievements is based on the statistical sign test.

Keywords – visualization, tools of computer visualization, visualization of the learning material, formation of skills to visualize, statistical sign test.

1. Introduction

The information education technology stimulated the changes of traditional approaches in teaching. Except involving the computer, the usage of Internet resources, the introduction of interactive technologies, there is the problem of the use of computer tools to apply visual methods of teaching which attracted the special attention of the scientists. New terms "visualization" and "visual support" appeared. They characterize involving of information technologies in the sphere of educational activity.

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If established regards on visual aids as on the base principle of teaching were not changed for long time, then the problem of the visualization of the learning material purchased new actuality with the appearance of multimedia.

The features of the work of the cerebral hemispheres in the context of perception of text material, data sets were described in the results of the psychologists' researches. The main thesis is that a human work with visual images is more rapid, that is why the idea of presentation of information content in its visual format (schema, table, diagram, graph, etc.) becomes popular. Thus, the visualization of the learning material as a pedagogical problem is still present in dissertation researches of the recent years.

2. The Analysis of the Terminological Field

An ordinary person identifies such terms as «visual aids» and «visualization». But the detailed analysis of scientifically and pedagogical researches on the problems of theoretical bases, kinds, types and tools of visual aids of the learning material and theoretical bases of visual support of teaching, visual thinking, the practical questions of creation of the tools of visualization, etc., certifies that these terms differ [1].

In Pedagogics the visual aids is identified with the basic principle of didactic approach. In accordance with it, teaching is based on certain images that are directly perceived by the subjects of teaching. It means that the visual aids are not necessarily linked with the visual perception of an object [2].

Determination of the visualization is given in different pedagogical conceptions [3]. It is characterized by taking away the thought forms, the form of which is spontaneously determined by the mechanism of associative projection, from an internal plan on the external plan in the process of the cognitive activity.

Based on the analysis of approaches the authors are sure that the interpretation of the term "visualization" has to consider not so much demonstration of an object, but creating of it. Such ideas caused the determination of the term "visualization" as a specific didactic category, which has more complete structure than traditional term "visual aids", due to

additional including teacher’s actions for the creating of the image of the learning phenomena. That is why the visualization is considered as a process of making the learning material clear whose demands not only represent the visual image, but also the process of its creating which provides including imagination, the establishment and the consolidation of associative links between learning objects and their structure elements.

This approach considers cognitive property of the visualization [4], [5]. Scientists emphasize that the visualization, which is included to the cognitive process, not only helps student to organize analytical and intellectual activity especially during the perception and processing of the information, but also offers meaningful knowledge, making a significant impact on the depth of the awareness of the perception and understanding of it.

It is wrong to assume that the simple demonstration of images, which model some object or its feature, is enough for understanding their idea or content. No one object’s feature is truly understandable for viewer without giving the object in a structure understandable form. The teacher has to help to percept not only by words, but also by structuring of the image [6].

The emphasized aspects are put in a basis of forming of future teacher’s skills to visualize the learning material. It is not enough to just show the learning object, it is important to predict all required properties for its imaginary modeling and after that to be able to create it.

Psychologists mentioned the opportunity to organize the meaning of the images as a main function of the visualization. Unlike the use of ordinary visual aids, the visualization is an activity in a special environment, which helps to “translate” one way of giving the learning material to another, to comprehend links and relations between its structural parts.

3. Methods of Visualization of the Learning Material

As the arsenal of teachers’ tools has expanded to using technological innovations (interactive whiteboards, multimedia projectors, readers, tablets) and specialized software, the problem of the formation of future teachers’ skills to visualize the learning material by multimedia tools is urgent. They help to not only show a theory clearly and give examples of its using in everyday life, but also to emphasize the essential properties of important concepts, relations and patterns of the world.

The authors found that the math-teachers preparation nowadays includes the implication of interactive software like GeoGebra (dynamic mathematics software) for which the teachers and the

researchers all over the world offer own applications. [7]. They are based on Java technology and the ideas of visualization and modeling of processes for the interpretation of complete concepts, some patterns and their properties based on mathematical methods [8]. Additionally, more abstracted from the subject field techniques of visual representation are using [9].

In particular, the compaction of the learning material is based on traditional charts and graphs (Fig. 1), denotation graph (Fig. 2), Fishbone schema (Fig. 3), building method (Fig. 4), causal chains (Fig. 5), strategy maps (roadmaps) (Fig. 6), radial spider-schemas (spiders) (Fig. 7), mind-maps (Fig. 8), etc.



Figure 1. The Example of Graphs

Denotation graph (Fig. 2) is a method of isolating essential features of the key concept from the text. In the applying of this method, it is important to choose a verb that links key concept (noun) and its essential feature. In other words, there is a gradual separation of the key words on “words-branches” for the exception of any contradictions. The characteristic feature of this method is the alternation of "noun-verb-noun-verb..." which demonstrates the dynamics of thoughts, the movement from the concept to its essential feature.

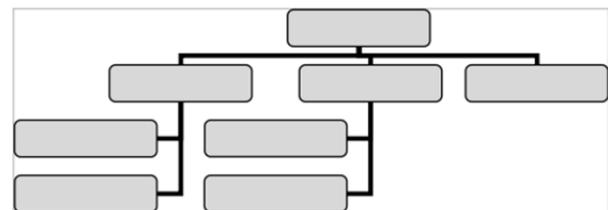


Figure 2. The Template of Denotation Graph

Schemas "Fish bone" or Ishikawa diagrams (Fig. 3) are visual forms of the learning material that resembles a fish skeleton. The main idea is fixed on the main backbone; the descriptions of the issues that affect the main idea are joined to it like bones. The schema is consistent with the following algorithm:

- the collection of facts that influence the idea;
- the grouping of the facts of semantic and causal blocks;
- the ranking of facts within each block;
- the analysis and discarding those factors, on which we cannot impact;
- the ignoring the insignificant and unimportant facts that are already fixed.

The conclusion is made by analyzing the pairs (factor-argument).

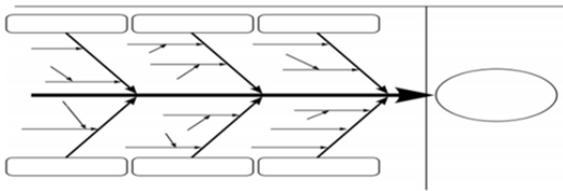


Figure 3. The Template of Fishbone Schema (Ishikawa Diagram)

Building method (Fig. 4) is applied to visualize the fundamental theories, their general structure or their part. The methodological level of the theory is fixed in the foundation of the building, the theoretical level is the housing, and the application level is the roof.

The main idea of the technique of using causal chains (Fig. 5) is explained in its title. The word "causal" means, "which is due to a specific cause". This method of visualization demonstrates the image of the cause and the result at the same time.

The strategy map (Fig. 6) is quite simple way to display the strategies, ideas, tasks and directions of development. It is often used in the humanitarian sphere, the economy, and politics.



Figure 4. The Template of Fishbone Schema

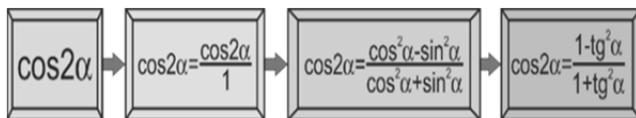


Figure 5. The Example of Causal Chain



Figure 6. The Example of Strategy Map

Spiders-schema (Fig. 7) is a kind of diagrams, which structure resembles the spiders: the main idea is in the centre, the results and the clarifications diverge from it.



Figure 7. The Example of Radial Spider-Schema

Structurally-logic schemas have the greatest information capacity, the versatility and integration. They are similar to mind-maps. This method of systematization and visualization of educational information based on the identification of significant relations between knowledge elements and analytic-synthetic activities in translating verbal information into nonverbal (visual), synthesizing a coherent system of knowledge elements. (Fig. 8)

Structurally-logic schemas are a special kind of visual aids. They put elements of the content in a nonlinear form, highlighting the logic relations between them. Such visual aids are based on the structure and association links of long-term memory. The idea does not demonstrate the content of the subject of education, but being connected by a system, they show the object's structure, its tasks and ways of development.

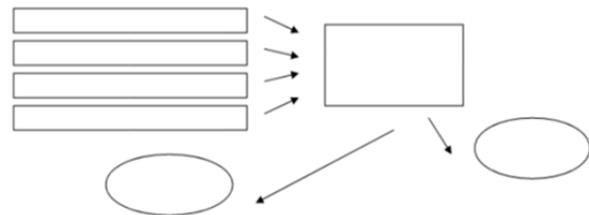


Figure 8. The Template of Structurally Logic Schema (event-cause-result)

The basis for the creation of mind maps (Fig. 9) is the radiant thinking theory. There is main object, from which central topics are separated by smooth lines. Then each topic is branching to the secondary ideas by the same smooth lines (branches), and all the branches in this construction form a connected structure. Each element in this schema (mind map) should cause the observer some association. The number of the associations that have been used, we can assume as database or archive. Because of using this type of multi-processing system and information storage, the brain in any time contains such "information maps", which have complete structure of a high level [10].

Another approach lies in the construction of interactive applets (Fig. 10), where not only dynamic of models is used, but also the offer to come to a conclusion or formulation of laws based on them. The creating of applet is a new problem in

educational researches [11]. The experience of their use in education shows that applets can provide a real help to students in learning the complete concepts. Only in the case, if the both design of applets and the organization of the learning activities of students with their use are carefully planned and reasoned methodologically. In particular, dynamic models, which are created by dynamic mathematics software, which provides not only interactive changes of the model, but also display the correct numerical parameters in dynamics, are interesting.

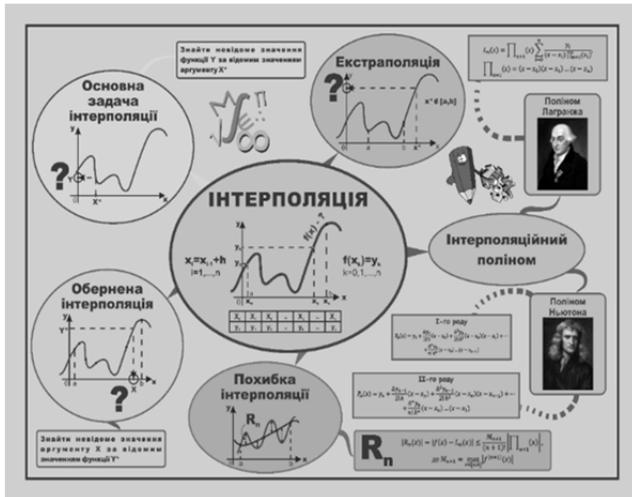
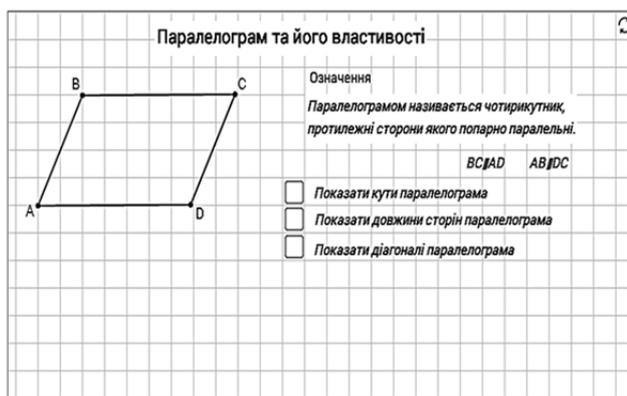


Figure 9. The Example of Mind Map

Java-applets and Flash-movies are examples of applets. Applets that are created for math curriculum called mathlets, for physics – physlets.

← GeoGebra

Паралелограм та його властивості



Завдання №1
Переміщючи точки A, B і C ви можете змінити розміри і форму паралелограма. Користуючись комп'ютерною моделлю «Паралелограм та його властивості» дослідіть:
1. властивості кутів паралелограма;
2. властивості сторін паралелограма;
3. властивості діагоналей паралелограма;
4. опишіть хід досліджень;
5. результати досліджень сформулюйте у вигляді теорем та спробуйте їх довести.

Figure 10. The Example of Interactive Applet based on GeoGebra

Another one innovative approach to visualize the learning material is scribing. Compact representation of material, audience attention on specific images which are created simultaneously, focuses attention on pre-defined key points of the learning material.

Scribing came in education from business applications, where scribing is the support-illustrated presentations. The scribing is a new technology of presentations, the essence of which is in synchronous support oral presentations (reports, speeches, presentation of the learning material, etc.) by marking drawings on a white board (or on paper). Scribing provides a specific kind of the support – the illustration "on the fly", which gives a special emotion and opportunity to focus the audience attention on the main objects. The appearance of scribing is associated with British artist Andrew Park, who offered this technology to popularize the scientific knowledge.

Scribing uses the same principle as the doodle – drawing by hand, and it forces the observer to focus his attention on the process, is in expectation what will happen next, thereby plunging to the learning problem [12].

Realizing the importance of these methods of visualization in the learning process at secondary schools, the authors have investigated the formation of skills to visualize the learning material based on computer tools, which provide the graphic constructions tools, design, diagrams constructions, interactive illustrating of some characteristics of modelled objects, relations between them. The authors have jointly called them the tools of computer visualization.

Among the tools of computer visualization the authors have identified dynamic mathematics software for mathematical modelling, virtual physical and digital laboratories for the simulation of physical processes, mind-mapping software, software for creating presentations, integrated development software environment, text and spreadsheet processors with specialized tools, graphical editors, etc.

Table 1. Tools of Computer Visualization

Type of visualization	Tools of computer visualization
Notes, Frames, Graph-schemas, Scribing	Graphical editors
Logical and symbolic models, Mind maps	Free mind, The brain, Xebece, CmapTools, Mindjet MindManager Pro, Microsoft Visio, Aibase, 3D Topicscape, AXON Idea Processor, Xmind
Flow charts	Pencil Project, Alglib flowchart editor, yEd.
Applets, Dynamic models	Dynamic mathematics Software (GeoGebra, Cabri, The Geometer's Sketchpad).

Our research on using of different methods of the visualization of the learning material by teachers

(102 respondents from 23 secondary schools of Sumy region) showed that the visualization of the learning material occurs in the lessons of natural science and mathematical, technological training tendencies by using of different technologies of visualization. However, such a representation is usually associated with a static modelling on the board and does not affect the process of visualization as a dynamic support for the interpretation of the concept, the demonstration of the fact or the confirmation of the law by the use of specialized computer tools.

In particular, teachers noted:

- the limited access to computers, that makes the involvement of the tools of computer visualization in the educational process difficult – 89%;
- the lack of free time of teachers to study the tools of computer visualization – 76%;
- the lack of sufficient numbers of teaching guides on the involvement of the tools of computer visualization in the educational process – 83%.

While scientific and methodical searches, we often heard comments from teachers that:

- the involvement of the tools of computer visualization is not sometimes justified from the point of time of their use – 65%;
- it is impossible to form qualitative idea about the concepts which studying by the tools of computer visualization – 50%;
- the elected tool of computer visualization is often not the most comfortable at the lesson – 23%.

4. The Formation of the Skill to Visualize the Learning Material by the Tools of Computer Visualization during The Special Course

On the one hand, the mastering of such tools will contribute the formation of students, future teachers, skills to visualize the learning material. On the other hand, it will encourage to the formation of a critical view on the tools of computer visualization as on a tool of professional activity of teachers. Considering this, we have introduced a special course "Current approaches to visualization of knowledge".

The content of the Special course was specified during 2014-2016 years at the Physics and Mathematics Faculty of Makarenko Sumy State Pedagogical University during the math, physics and computer science teachers' preparation.

The main aim of the Special course is to form competences in the field of visualization of various kinds of information, including the learning material.

The objectives of the Special course are the mastering of the techniques of visualization of the learning material, the familiarity with the tools of computer visualization, their classification and instruments, the formation of skills to visualize the learning material by the most popular tools of computer visualization.

The Special course has 4 credits (120 hours, including 40 class hours), consists of two modules and studied at the fourth year. The first module concerns the specialized mathematics software (systems of computer mathematics (SCM) and dynamic mathematics software (DMS)), because the dynamization of phenomena, processes and laws is possible based on mathematical modeling. The second module concerns the visualization techniques and study of specialized tool. In particular, mind-mapping software, flow charts building software, creating of presentations, graphical editors, dynamic mathematics software, etc. are analyzed and studied.

In our scientific-methodical search, we were guided by the thesis: the skill to visualize the learning material will be formed if the future teacher will possess:

- 1) ideas of techniques of visual representation of information (mind-maps, Fishbone schemas, notes, frames, flow charts, graph-schemas, applets, dynamic model, scribing);
- 2) understanding ways to use the tools of computer visualization during the study of each topic (static visualization or dynamic demonstration during studying of a new topic, studying of properties of given object, searching of patterns, organization of project work, etc.);
- 3) ideas of instruments of the tools of computer visualization (possible visualized forms, color accents, thickness of lines, interactivity, 2d and 3d building formats, calculation, conversion, application settings, etc.), methods (dynamic calculations, step by step demonstration, basic constructions, etc.);
- 4) skills to use the instruments of the tools of computer visualization to support educational activities efficiently.

The mentioned items could be implemented during lectures or independent study of literature and electronic periodicals, and during work with different tools of computer visualization. During the study of the Special course, we offered to study several tools of computer visualization, the list of which is first determined by the recommendations of leading experts in the field of information education and our own experience, and then changed due to the updating of the versions of some software or the appearance of new analogues (Table 2).

Table 2. The Tools of Computer Visualization, which are Studied

Years	The tools of computer visualization
2014-2015	SCM, DMS, graphical editors, text and spreadsheet processors
2015-2016	SCM, DMS, graphical editors, text and spreadsheet processors, mind-mapping software
2016-2017	SCM, DMS, graphical editors, text and spreadsheet processors, mind-mapping software, software for creating presentations

The Special course envisaged to involve selected tools of computer visualization to solving didactical and methodical problems on various topics, visual support of theoretical material using all possible methods of visualization. Students had to develop visual support of proposed material (concepts, laws, tasks of given topic) in each of software during laboratory course.

In this way, the authors tried to form not only the future teacher’s skill to work with the various tools of computer visualization, but also examine the number of steps for solving the same problem in different tools of computer visualization, the availability of needed instruments in given tool of computer visualization, possible and impossible form of visual support in given tool of computer visualization, etc.

5. The Research of the Effectiveness of the Special Course on the Formation of the Skill to Visualize the Learning Material by Tools of Computer Visualization

To determine the effectiveness of this special course the authors selected the following method. At the beginning of the course we asked students, future teachers, to offer visual support of given topic with four visual forms based on their own experience. At the end of the course we offered the same task, but using the tools of computer visualization.

Since we studied the impact of the special course on the formation of the skill to visualize learning material of each student, dependent results, but independent samples were needed. That is why we have used the sign test, which allows us to work out these results by statistical laws.

We thought that the student has the formed skill to visualize the learning material, if he can submit it in a visual format no less than in three ways and uses the tools of computer visualization.

The results of the evaluation of 30 students, selected at random from samples (2014-2016), are given in Table 3.

Table 3. The Results of the Evaluation of 30 Students

№ Student	The first mark			№ Student	The second mark			№ Student	The second mark		
	The first mark	The second mark	The result		The first mark	The second mark	The result		The first mark	The second mark	The result
1	1	3	+	1	1	3	+	2	3	4	+
2	0	1	+	1	4	3	-	2	0	3	+
3	3	3	0	1	1	3	+	2	2	2	0
4	1	3	+	1	1	3	+	2	3	2	-
5	1	1	0	1	3	3	0	2	0	3	+
6	3	3	0	1	0	1	+	2	0	1	+
7	1	3	+	1	2	3	+	2	2	1	-
8	3	2	-	1	2	2	0	2	4	4	0
9	3	4	+	1	2	3	+	2	2	3	+
10	2	2	0	2	3	3	0	3	2	4	+

In accordance with the purpose of the experiment, the authors formulated the hypothesis H0: the study of the Special course does not affect the formation of the skill to visualize the learning material. Then Hα: the study of the Special course affects this formation.

These hypotheses determine one-sided sign test for testing dependent samples. According to the decision rule the value of Texp=17 (the number of characters "+" in the sample), n=21 (the number of respondents who had changes in the results), the interval of the hypotheses H0 [6, 14] on the significance level of 0.05 (determined by the corresponding table in [13]).

Since Texp is not included in the acceptance interval of the hypothesis H0, the hypothesis H0 is rejected and the alternative hypothesis Hα is accepted. Thus, the Special course contributes to the forming of skills to visualize the learning material. The value of Texp went beyond the segment to the right, so a conclusion about positive dynamics in the number of students who have formed the skill to visualize the learning material with tools of computer visualization was made.

6. Conclusion

The visualization of the learning material in its various forms allows us to solve a number of pedagogical tasks: the ensuring the intensification of education, the activation of educational and cognitive activity, the formation and development of critical and visual thinking, visual perception, visual representation of knowledge and educational actions, knowledge transfer and image recognition, the improving visual literacy and visual culture.

The interest in visualization is stimulated by the development of computer software that not only expanded its scope, but also influenced the nature of the teachers' professional activity. The tools of computer visualization, which help to create visual models, diagrams, links between objects of study, need a special attention of the teacher.

During the teacher preparation, aimed at process of visualization with the use of multimedia technologies, the main visual aids didactic principle is implemented, the deep internal relations are revealed, associative links are formed, and the theoretical foundations of the law and its interpretation are confirmed. Therefore, there is the reason to believe that the formation of the skill to visualize the learning material provides training and further self-realization of the modern teacher, as it requires not only an understanding of the technological foundations of the process of dynamic visualization, but also mastering of computer tools and skills to use them in solving professional tasks.

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