Formation of Future Teachers' Skills to Create and Use Visual Models of Knowledge

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Abstract **– The article proposes a solution of the problem of formation of future teachers' skills to create and use visual models of knowledge in professional activities. It is substantiated that modern students, as representatives of the generation Z, have the majority of visual-oriented perceptions. Modelling of special future teachers' preparation for the creating of visual models of knowledge is made. The content of the special course, aimed at forming the future teachers' ability to create and use visual models of knowledge, is described. The pedagogical experiment included two areas of research: the study of the dynamics of the readiness and the formation of skills to create and use visual models of knowledge. Statistical methods confirmed the effectiveness of the author's special course at the significant level of 0.05.**

Keywords **– teacher training, visual models of knowledge, visualization technology, visualization, visibility.**

1. Introduction

Modern education is characterized by the intensification of the educational process, which is caused by various factors, among which: the active development of information technologies and the exponential growth of informational and educational content. This exacerbates the anxiety of the educatees: they do not believe in their own strength to master it.

The survey of teachers from various Ukrainian educational institutions (the total number of respondents – 203 persons), conducted in 2015-2016, showed that due to the large volumes of educational material, the subjects of study refuse reading long texts and often search for answers within one page (screen). Such a phenomenon was called "clip" perception of messages [1]. It is when the consciousness catches a small but bright piece of material that remains in memory. Usually, such a fragment attracts attention due to the interesting detail, colour accent, and so on. If the information has not attracted the attention of users, it may remain unexplored.

This condition was confirmed by a survey of student youth (the total number is 276 people): subjects of study show a desire to answer the tasks independently (53%), instead they refuse to search for answers in long-term texts (84%). The survey shows that images (82%), vivid pattern drawings (91%), and interesting dynamic presentations (76%) are mostly stored in memory. Therefore, the urgent need of time is the integration of information and communication technologies, the visual technologies and the polysensor representation of educational material. In this case, it is important to perceive the visual image as a complete information unit.

The analysis of scientific works related to such integration revealed a number of contradictions:

- identification of the terms "graphics", "visibility", "visualization", "infographics", "visual models of knowledge", etc., and the need for their coherence;
- borrowing visualization technologies from the sphere of advertising and business into the educational sphere, copying information images, construction of direct analogies, appearance of

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stereotypes, patterned examples and lack of intellectual, scientific basis;

- active introduction visual, cognitive-visual approaches to learning into the educational process and the lack of appropriate skills to develop and use visual models of knowledge for future teachers;
- direct identification of the visualization methods of educational material with the subject of informatics and the decline of the idea of forming a creative person, who is often limited only to the use of the studied software in the field of computer graphics.

The contradictions mentioned above determine the importance of developing skills of creating and using visual models of knowledge for specialists in any sphere, and, especially, for future teachers who are responsible for the quality of the younger generation preparation for life in the information society.

The results of psychological and pedagogical research in the field of visualization of educational information are presented in works of different levels and formats [2], [3], [4]. S. Aranova [5], V. Dalinger [6], V. Davydov, P. Erdinev, L. Zankov [7], V. Zinchenko, G. Lavrentyev, N. Manko [8], O. Peskov, G. Perevalov [9] and others investigated the theoretical basis for the visualization of educational information. For example, S. Aranova [10] emphasizes the formation of intellectual and graphic culture, which contributes to the self-assimilation of a unit of educational material through visual-shaped models of knowledge.

The study of the peculiarities of visual thinking is devoted to the scientific studios of R. Arnheim, N. Reznik [11] and V. Skvyrsky. The theory of perception and assimilation of educational material based on the use of the visibility principle is at the center of the research attention of V. Bespalka, L. Vygotsky, O. Leontiev, N. Talizina, I. Yakymanska, and others.

According to psychologist R. Arnheim [12], the use of the potential of visual thinking activates cognitive activity, because visual content is faster and better remembered, causing certain associations and persistent stereotypes. In the context of this we cannot agree with O. Zhurkin, who stresses that the use of visual images simplifies information; such models, by contrast, enrich the perception of subjects of learning and through associative thinking contribute to the formation of interdisciplinary and supra-object relationships [13].

L. Belousova and N. Zhitienova [14] also emphasize the importance of the visualization principle in education, which, based on a functional approach, proves importance of using educational visual models of knowledge in the educational process. T. Gavrilova, I. Leshcheva, E. Strakhovich [15] emphasize the necessity of training the basics of visual modelling for future specialists using visual conceptual models of knowledge and formation professional culture on this basis.

Some questions regarding the use of specialized software for visualizing mathematical objects in the preparation of a math teacher are also presented in our publications. We studied the importance of formation of the future-math-teacher readiness to use the dynamic mathematics software as tools for visualizing mathematical knowledge (environments where it is possible to create and operate mathematical objects to study their quantitative and qualitative characteristics) [16], [17]. As our findings have shown, the skills of mathematics teachers to visualize mathematical knowledge contribute to the assimilation of the subject, process, phenomenon and the formation of a holistic semantic image and activate visual thinking, stimulate the formation knowledge.

At the same time, the analysis of scientific research revealed lack of scientific works about training specialists to develop and use visual models of knowledge in professional activities. Insufficient research is being made on the training teachers to create and use visual models of various types based on different software.

2. Method

In order to fulfil the research tasks, such theoretical and empirical methods were used:

- analytical and synthetic method – to determine the contradictions and confirm the relevance of the research problem, the justification of the methodological basis of specialists' training to the development and use of visual models of knowledge;
- the method of synthesis and terminological analysis for combining in a single whole the disparate concepts and interpretations in the field of visual communication and the culture of future specialists' visualization;
- figurative and symbolic approach as a method of studying the peculiarities of the subjects of learning communication (natural and mathematical specialties teachers), which is applied to study the requests of a specific audience according to the type of educational content, its description and interpretation within the limits of their value characteristics;
- surveys, questionnaires, interviews with teachers concerning the formation of students' visualization skills (development of visual models of knowledge);

- statistical methods of processing the results of experimental learning (nonparametric criterion of signs and method of student average assessment) to confirm the effectiveness of the author's special course.

The study was conducted based on Makarenko Sumy State Pedagogical University during 2015-2017. Students of the 4th year, future mathematics, physics, chemistry, computer science teachers (123 persons) participated in the pedagogical experiment. The results of the experiment are statistically processed and verified according to the nonparametric sign test and Student's test. The selected level of significance is 0.05.

3. Results and Discussion

A prerequisite for sustainable development and one of the main indicators of the country's development is the quality of education. However, in fact, the quality of education is often inert regarding technologies that are the part of young people life. If computer technology is already an integral part of the education system, then the characteristics of the younger generation, which has "grown" on these technologies, are still not sufficiently taken into account by educational institutions.

M. Isaeva [18] confirms this. The researcher emphasizes: as a result of the development and spread of computer technologies (based on the digital signal transmission method), the generation of children born at the end of the 20th century and later, from an early age, were in a digital, computer-oriented, mobile and mostly virtual environment. This generation is often named as the Z generation (or digital, digital aborigines, artists).

According to the theory of generations proposed B. Strauss and N. Howe, each generation has its own type of behaviour and values that depend largely of the society conditions, in which the child grew and was brought up. The model of the behaviour of the generation, as evidenced by the researchers, is repeated cyclically: values and psychological peculiarities of every fifth generation are somewhat like the first ones. Scientists have identified four patterns of behaviour: "Prophet", "Traveler", "Hero", "Artist".

Representatives of the Z generation are like the "artists" from 1925-1942 years (the so-called "silent generation"), however, are distinguished by a fundamentally new type of thinking and a way of perceiving information, because they have been immersed in the Internet space since the early years. If in previous decades the development of cognitive processes, emotional and volitional spheres and other psychological peculiarities took place through live communication, now the online environment carries out the prevailing influence on these processes.

According to the psychologists' observation [19] and according to psychodiagnostic studies of the first-year student personality, conducted in 2011 in Pavlov First Saint Petersburg State Medical University (Russian Federation) [20], children of generation Z:

- better perceive information provided in small portions and with interruptions ("clip thinking");
- do not understand complicated material, cannot absorb large volumes of text information;
- wishing to work with templates;
- have a predominantly visual type of information perception;
- are well motivated through the elements of the game in training (in contrast to the previous generation, for which the competition among peers was a priority), are quickly distracted, if there is no such element;
- have weak mechanisms of self-regulation (control, modelling, evaluation) and, as a result, are not able to independently look for solutions, organize time for learning, distribute time and psychological resources in the learning process;
- are characterized by low level of responsibility and high level of self-confidence;
- have undeveloped communicative skills, do not know how to speak and speak with structured reports;
- are strongly expressed individualists, have considerable intellectual potential;
- easily orientated in information resources;
- spend a lot of time on social networks, so they are enthusiastic about the opportunity to publish the results of their own education;
- above all, they appreciate the moral and physical comfort of the learning environment.

Such characteristics are unique and important during the organization of the educational process. R. Isaeva [16], for example, proposes to use actively the visual models of knowledge in the educational process, which necessitates appropriate training of specialists and especially teachers as bearers of knowledge.

The identified need for teacher training has led to an analysis of scientific sources on developments in this field.

The theoretical analysis carried out by us allowed us to identify conceptual dissonance in terms of "graphics", "visibility", "visualization", "infographics", "visual models of knowledge".

Terminological analysis allowed distinguishing the given terms (Table 1.).

Table 1. Terms interpretation

Term	Interpretation	Source
Visibility	- Subjects used to be shown during training; - Learning method based on the use of such subjects; - "Golden Rule" of the didactics proposed by Y. Komensky: "Everything that is possible must be imagined by sense: visible – sight, audible – hearing, sniffy – smell, taste – taste, touching – touch. And if something can be simultaneously perceived by several feelings, it must be filed simultaneously.	[21], [22]
Graphics	Kind of fine art; comes from the Greek word "grapho", which means to write, draw, scrape	[23]
Visualization	- Interactive study devoted to the visual representation of abstract data in order to enhance human cognition. - The process of transformation, compression, curtailment of educational material into a visual image, which requires not only the reproduction of the visual image, but also its design.	[24], [25]
Infographics	- Graphical visual representation of information, data or knowledge intended for the rapid and accurate display of comprehensive information. Enhances the visibility of the human system to see patterns and trends. - The process of creating infographics is considered as data visualization, creation of information schemes and models of information presentation.	[26]
Visual models of knowledge	- The result of the visualization process. - Any construction perceived clearly and reflects the essence of the object of knowledge. - The result of a certain stage in the formation of knowledge, including theoretical, in a visual form reflects the results of such a formation, reveals shortcomings and contradictions.	[27], [28], [29]

The terminological analysis revealed that visibility couldn't be identified with visualization; these concepts intersect, but have their own characteristic differences. The graphic includes infographic as a kind, and visual models of knowledge can be presented not only in infographic but also in an artistic way.

The analysis allowed distinguishing methods of visualization of various information materials (educational, quantitative, formulaic, etc.):

- tables are structured units of information containing a list of statistical or other data, which are arranged in a certain order and grouped by rows and columns;
- charts, graphs, etc. in the general sense are images of the dependence (often quantitative) between certain quantities;
- schemes, causal chains are drawings, which graphically represent the ratio between the comparable values;
- Smart-Art objects are simplified presentation of a certain subject, process, device, concept or phenomenon with fixing of defining characteristics;
- mind maps are a way of representing the process of general system thinking using radial schemes.

The first three (tables, diagrams of different types, schemes, etc.) are often combined with one term "infographics". Some objects of Smart-Art also can be considered as infographic objects.

Thus, the development of visual models of knowledge is impossible without the teacher's ability to visualize educational material in different ways.

According to the results of the analysis, we established that future teachers are partially familiar with approaches of visualization the educational material on classes on the methodology of teaching and computer graphics classes. However, we did not find a systematic vision of the importance and the need to form skills for use of visual models of knowledge in professional activities. Special courses are also not present in the curriculum.

Therefore, the next task of our work was to simulate the special training of future teachers for the development and use of visual models of knowledge in future professional activities.

We suppose that the ability to create and use visual models of knowledge must be formed if the future teacher will have:

1) idea of ways of presenting visual models of knowledge;

2) idea of computer visualization tools – environment where developers provide opportunities for compact visual representation of various objects or processes, their modeling and research;

3) the ability to imagine and then reproduce knowledge models based on computer visualization tools;

4) skills to rationally use the available computer software of computer visualization tools to support the construction of models of knowledge.

The purpose of the special course is to form the ability of future teachers to create and use visual models of knowledge, including using computer visualization tools.

The main tasks of the special course:

- mastering various methods of constructing visual models of knowledge based on different types of educational material (text material, analytical or formulas, statistical data, time analysis, etc.);
- analysis of modern computer visualization tools, their classification and tools;
- formation of skills to create visual models of knowledge, including using computer visualization tools;
- formation of skills to use visual models of knowledge in professional activity.

The special course developed and implemented by us in the variational part of the teacher-training curriculum in the cycle of professional training. It takes into account the specific principles of learning, among which the principle of integration of knowledge, the principle of orientation to the computer visualization tools, the principle of cognitive imaging.

The principle of the knowledge integration requires the construction of a holistic learning process, where the subject area of the future teacher and information technology will complement each other for the presentation of the right visual models of knowledge. This principle is realized due to the actualization and use of interdisciplinary connections with the sections of informatics (computer technologies, graphics, programming, etc.), as well as the introduction of pedagogical methods in the methodology of teaching, the use of specialized software, subject-oriented software, etc.

The principle of orientation on the computer visualization tools involves the simulation of each type of educational activity aimed at attracting means of visualization or emphasizing the impossibility of doing so. This, in turn, requires changes in the priority approaches to learning (from knowledge to competency), the advantage of constructive approaches to analytical or computational ones. Implementation of the principle is particularly useful as a propaedeutic of using computer visualization and a demonstration of the potential ways of using computer visualization in teacher's professional activities.

The use of the cognitive visualization principle involves the disclosure of cognitive goals through a well-considered presentation of the educational material. In the context of the use of computer visualization tools, this involves the creation of cognitive models of knowledge that respectively use visual accents (color, line thickness, certain marks, arrows, sizes, etc.) to display the main properties and contribute to the generalization and systematization of knowledge about the classes of objects, processes, phenomena. We perceive the principle of cognitive visualization as a basis for the professional skills formation for the creation and use of visual models of knowledge in future professional activities.

A special course in 3 credits (90 hours, including 30 hours in classroom) covers two modules and is offered for fourth year students. The first module is devoted to studying the ways of educational material visualization and acquaintance with computer visualization tools, in particular, with office software smart-objects, mind mapping software, infographic software. Therefore, the first module focuses on the formation of knowledge about visual forms, visual simulation, etc., and knowledge about computer visualization and its tools. The second module focuses on the formation of skills of creation and use of such models in professional activities.

For experimental verification of the author's special course, we are expected to involve selected computer visualization tools in solving various professional tasks (students create visual models for typical concepts, laws, rules, tasks, even to topics and sections of relevant disciplines in each of computer visualization tools).

We propose some examples of tasks for the creation of visual models of knowledge offered by students.

Task 1. Create a model of knowledge using the SmartArt object (Hierarchy) based on the given text material.

Task 2. Create a mind map card for the proposed topics.

Task 3. Create a circle one with the corresponding inscriptions based on the column chart of the group's success.

Task 4. Describe its content based on a given infographic.

The execution of similar tasks helps, as the analysis shows, to formulate students' skills to create and use visual models of knowledge in future professional activities. In addition, it contributes to the formation of critical thinking of students on the

tools of computer visualization means in the context of constructing different types of knowledge models.

The author's special course had been introduced during 2015-2017 in the training of natural and mathematics teachers in Makarenko Sumy State Pedagogical University (Ukraine). 123 people attended the experiment.

Describing the results of the pedagogical experiment, we must highlight two areas of research: the study of the readiness dynamic (part 1) and the formation of skills to create and use the visual models of knowledge (part 2).

Part 1. Students at the beginning and at the end of the special course study were asked the following questions (for example, for math teachers see Table 2.).

Table 2. Questionnaire for future math teachers

№	Questions	Answer (1/0)
1	Is it necessary to use logic schemes when explaining the learning material?	Yes / No
2	Will you use the mind maps at the lessons?	
	a) Algebra;	Yes / No
	b) Geometry;	Yes / No
	c) Algebra and Elements of Analysis	Yes / No
3	Will you use scribing at the lessons?	
	a) Algebra;	Yes / No
	b) Geometry;	Yes / No
	c) Algebra and Elements of Analysis	Yes / No
4	Which software allow you to create a visual model of knowledge:	
	a) office software products;	Yes / No
	b) mind mapping software;	Yes / No
	c) dynamic mathematics software;	Yes / No
	d) infographics software;	Yes / No
	e) online games;	Yes / No
	e) cannot be created.	Yes / No
5	Do visual models of knowledge always contribute to improving the understanding of learning material in Mathematics?	Yes / No
6	Do visual models of knowledge always contribute to the intensification of the learning process?	Yes / No
7	Does a using visual model of knowledge provide a positive attitude to the process of studying Mathematics?	Yes / No
8	At what stages of the lesson is it expedient to use visual models of knowledge:	
	a) when updating background knowledge;	Yes / No
	b) when submitting a new material;	Yes / No
	c) when learning concepts and forming practical skills?	Yes / No
9	Should you, in your opinion, create visual models of knowledge when passing pedagogical practice?	Yes / No

Students could score up to 20 points. The scoring scale contains two titles: yes or no. The respondents of the sample are not dependent on each other, while the results of the two surveys (at the beginning and at the end of the special course each of the participants in the experiment) are dependent. This gives grounds for using the sign criterion. The results are presented in Table 3.

Table 3. Result of the achievements of the respondents

No. of respondent	I poll	II poll	No. of respondent	I poll	II poll	No. of respondent	I poll	II poll	No. of respondent	I o poll	II poll
1.	9	11	32.	11	15	63.	14	14	94.	12	10
2.	13	14	33.	13	13	64.	14	15	95.	12	12
3.	9	15	34.	12	14	65.	13	12	96.	12	9
…											
30.	9	17	61.	11	11	92.	12	14	123.	11	15
31.	14	12	62.	5	9	93.	13	16			

Hypothesis H_0: Special course does not affect the readiness to create visual models of knowledge, including using specialized tools.

Hypothesis H_a: Special course affects the readiness; the feeling of readiness is not accidental.

To check the null hypothesis we calculated the number of changes (the number of increase in the result and the number of its reductions). In our case, changes with "+" are greater than changes with "-", so the typical is positive shift (Table 4.).

Table 4. Description of changes in each respondent

No changes «0»	Changes with «+»	Changes with «–»
11	62	50

Number of non-typical shifts $G_{empir.}=50$, $G_{crit.}(0.05; 123)=55$.

Since $G_{empir.}<G_{crit}$ (50<55), we must reject the null hypothesis and accept an alternative one. In other words, the special course positively effects on the readiness to create visual models of knowledge, including using computer visualization tools.

Part 2. In parallel, we conducted research on the formation of skills of the creation and use of visual models of knowledge in professional activities by estimating average scores based on Student's test at the significance level of 0.05.

At the beginning of the 4th year of study and at the end of the training, test sections of students' achievements in the field of visualization of learning material were conducted (in the control and experimental groups). Future teachers were offered the following tasks.

1. Create a chart of a given type (circular, column, linear, etc.) for a given text fragment.
2. Describe the material presented schematically in words.
3. Develop a causal scheme (Ishikawa scheme, hierarchical, etc.) of a certain process.

The following results were obtained (Table 5.)

Table 5. Statistical results of the experiment

Groups	Number	Unsatisfactory (1-40 points)		Satisfactory (41-60 points)		Good (61-75 points)		Excellent (76-100 points)		Average level	
		Before	After	Before	After	Before	After	Before	After	Before	After
CG	105	22	28	53	60	24	30	6	5	60,9	60,3
EG	123	18	15	49	40	25	51	13	17	63,8	67,8

According to the Student's test of averages comparison we got the statistical similarity of the groups ($T_{stat}=0.36<T_{exp}=1.97$) at the significant level of 0.05 at the entrance to the experiment, and difference at the output ($|T_{stat}|=2.03>T_{exp}=1,97$), which cannot be explained by accidental reasons.

4. Conclusion

1. Visualization is currently a means of communication for the young generation in the era of information society. This generation differs in a fundamentally new type of thinking and a way of perceiving information within the majority due to vision sense and by small portions (clip) of information. Therefore, the educational industry in the conditions of intensive development of IT should orientate on the visual presentation of learning material. Such a presentation as a way of consolidating, but not reducing, information content should be used as an effective approach to activate cognitive activity during the teachers training.

2. It is necessary to distinguish the terms "graphics", "visibility", "visualization", "infographic", "visual models of knowledge" and their role in educational process, because they have a different meaning. In vocational education, it is expedient to use separate terms in the following meaning. Visibility is something that can be demonstrated during studying. Visualization is the process of transformation, compression, curtailment of learning material into a visual image, which requires not only the reproduction of the visual image, but also its design. Infographics is a graphical representation of data or knowledge designed to display comprehensive information quickly and accurately and is intended to facilitate models, processes and trends in human vision. Visual model of knowledge is the image of a certain stage of knowledge formation, which reflects the results of such a formation, reveals shortcomings and contradictions in a visual form.

3. Perception of the visual image as a unit of educational information causes the need for comprehension in the conceptual and methodological aspects devoted to the teacher's ability to create and use visual models of knowledge and computer visualization tools to provide meta-object learning results. Therefore, the teacher's preparation needs to be improved in part of his ability to create and use visual models of knowledge in his own professional activity. We offered a special course, designed to form the ability of future teachers to create and use visual models of knowledge using computer visualization tools. Course study should be based on specific principles of learning, among which: the principle of knowledge integration, the principle of orientation to the computer visualization tools, the principle of cognitive imaging.

4. We have developed a special course aimed at forming the skills of future teachers to create and use visual models of knowledge in professional activities (level of significance as 0.05 confirmed its effectiveness).

At the same time, it is incorrect to assume that visual models of knowledge can completely replace verbal and textual ways of presenting learning material. However, the integration of such methods will help future professionals to understand the meaning of the surrounding reality and build their own picture of the world.

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