The Role of Infographics for the Development of Skills for Cognitive Modeling in Education

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Abstract—Contemporary culture is a visual culture. Visual images become the predominant form of communication. Students should be visually literate and be able to read and use visual language, to decode, interpret and evaluate visual messages successfully, and, last but not least, to encode and compose meaningful visual communication. The combination of modeling with other methods in scientific knowledge increases its potential as a cognitive method. Infographics can play a significant role in the process as tool or target according to the age and cognitive abilities of the students. Information images (infographics) are visual representations of information, data or knowledge. The use of infographics as a modeling method can develop different cognitive skills such as interpretation, analysis, assessment, conclusion, explanation, which are all part of the modeling process. In fact, they can be a tool for achieving the next stage of literacy - visual literacy. All this necessitates the exploration of infographics as an instrument in the development of a comprehensive system of cognitive tasks in education related to the formation of skills for modeling. In the paper, six types of cognitive tasks in education are analyzed as well as their relation to the visual literacy competence standards approved by the Association of College & Research Libraries. A comparison of freely available infographics tools is provided and the suitability of different infographics templates is discussed.

Keywords—model, constructivism, visualization, infographic, visual literacy competence, education

1 Introduction

The role of the model as a cognitive tool and of modeling as a cognitive method is primarily related to their importance as a system by which the original is presented in a simpler form, i.e. its essential features, signs and properties are separated to explore and study, and the new knowledge obtained is transferred to the original itself. Combining modeling with other methods in scientific knowledge increases its potential as a cognitive method. However, in many cases, this is either impossible or unnecessary, as there are some principal limitations. Each model only reproduces distinct peculiarities, traits and features of the original, and therefore does not fully reflect the real

properties of the object, processes and phenomena, although in all modeling cases the limits and conditions for its applicability should be indicated.

Cognitive modeling in education as a method or activity in training is seen as a purposeful and synchronized system of actions. Analyzing modeling in cognitive activity focuses attention on the search for opportunities to form and develop fundamental skills that lie at the basis of the competence for cognitive modeling, namely:

- exploring objects and revealing their essential properties;
- systematization and summarization of essential source information for the object under survey in a mental, verbal, visual or other form;
- building models;
- selecting models (selecting the most appropriate model for the particular situation);
- practical and/or theoretical verification of models;
- coding, decoding and transcoding information in and through models;
- transfer of knowledge obtained for the model as knowledge of the subject being studied;

In order to be able to implement the cognitive functions to their full extent in the course of the development of a competency for cognitive modeling, it is necessary to determine the didactic conditions for this. The objectives and outcomes identified through the education curriculum for the particular educational level include not only the mastering of certain knowledge and the formation of skills and attitudes, but also the actions concerning their assimilation and formation, which are directly related to the development of the cognitive abilities of students.

Our modern days are characterized by a „visual boom“ through which the information society of the 21st century passes, saturated with information produced by visual sources through visual means. Therefore, one of the conditions for the optimal application of modeling in cognitive activity is related to the principle of visibility, according to which it is necessary to ensure easy perception of the information contained in the models (which may be infographics specifically created for that purpose or made by students themselves), according to the age and cognitive abilities of the learners.

There are currently a limited number of publications demonstrating the use of infographics as a learning tool. Partial studies (pedagogical experiments) have been conducted which explore the use of infographics at different stages of the learning process [1, 2, 3].

2 Infographics as modeling method

Today, the world is becoming more and more saturated with information. There is a need for mechanisms to help us handle this vast amount of information more easily. Infographics can play an important role in simplifying this information and in improving data processing so that it becomes much easier and faster.

Information + Graphic = Infographic

An information image (infographic) is a visual representation of information, data or knowledge. It differs from ordinary images and photos, as it provides information in a specific and practical way. It can be used for signs, maps, and technical documents that require a quick and clear explanation of complex information. Infographics include elements such as charts, maps, logos, calendars, illustrations, and graphics.

There are three main types of infographics:

- **Static** - the simplest and most common type of infographics. Often consists of one image without animated elements in it.
- **Interactive** - dynamic composition containing animated elements. Users can, to some extent, interact with individual elements and data. This type of infographics allows the visualization of a larger amount of data in a single view.
- **Video Infographics** - a visualization that is achieved with short videos combined with visual images, illustrations and text.

In addition to its functionality and performance, infographics can also be categorized as statistical, time-line, process-based, geo-locating, visual storytelling. In terms of structure, unlike ordinary images, the infographics visualize the relationship between at least two types of entities, one on the independent axis (or I-axis) and another on the dependent axis (or D-axis) [4].

Through their structure, design and communication signals, infographics recreate and transmit information from a higher level. What is important for each infographic is its consistent and logical design, appropriate visual elements such as text and images, the capacity to attract and retain attention, and a clear and visible connection between the entities within it [5].

The visual presentation of the study content can be performed as *demonstration* and *visualization*. While demonstration occurs mostly with ready-made objects, processes and phenomena, visualization is representation in the form of a model. In other words, in the learning process the information needs to be rationalized and presented in the form of figures, text and images. The very process of visualization is shrinking content for rationalization and presentation with patterns to serve as a basis for thought and practical action. This type of facilitating the interaction between the student and the study content is especially important nowadays to contemporary learners for whom "inhabiting virtual realities is much more than a new kind of pastime. Rather, it sets up a mode of perceiving and interacting with the world around in which the resolution of a dilemma, the overcoming of a difficulty, the discovery of something new, important or necessary is a matter of a single click of the mouse or just a touch of the screen. This in turn leads … to the illusion that in reality problems, conflicts and difficult situations have a restart key… The evidence that this type of thinking is typical of modern children [students] is …their refusal to handle and interpret texts from course books. Their expectations are not that teachers should educate them but that they should "transform" these texts into understandable language" [6]. The present study shows that an efficient way to do so is to use infographics as a way of encoding study content in a manner accessible to students.

Infographics include three main components - visual elements (colors, graphics, signs, icons, maps, etc.), content elements (facts, statistics, texts, references, etc.), and

knowledge (conclusions, messages, etc.) [7]. Infographics recreate content to convey the knowledge they carry. This is actually achieved through a combination of content, design, and technology.

The use of infographics as models and their application as a modeling method creates conditions for the development of different cognitive skills such as interpretation, analysis, evaluation, conclusion, explanation. In fact, these are among the basic tools for achieving a higher level of visualization competence.

3 Developing modeling skills through infographics

The order of students' familiarization with a variety of models which differ in their difficulty level and complexity is associated with the estimation of students' abilities to apply these, which requires that the best combinations of models should be established so that they complement each other and reflect significant characteristics, aspects, and properties of objects from reality. This provides for studying these objects, processes and phenomena from diverse and numerous perspectives thereby forming improved perceptions of the nature of objective reality based on the gradual application of models of higher levels of complexity. In this case, any model can be regarded as a combination of several models, which are to be explored in a relatively isolated manner and in accordance with the condition for the analysis of models in sets, with regards the respective levels of cognition.

The development of students' cognitive abilities through the formation of cognitive acts for the internalization and interpretation of knowledge to the degree of skills for cognitive modeling in education requires self-dependence and creativity – qualities, which can both be stimulated by infographics.

Education is a constant flux from the sensory to the abstract and from the abstract to a new type of sensory experience. The mastering of a system of knowledge on the specific and on the general (concepts, laws, and theories) is a process of cognition characterized by continuous construal of models and by the application of modeling as a cognitive activity in education. This process entails the coding, recoding, and decoding of information in the course of the incessant flux from the concrete to the abstract and vice versa. This necessitates the establishment of a purposeful application of logical methods, such as analysis, synthesis, induction, and deduction as a condition for the development of the competence for cognitive modeling in education.

The educational process is predicated on and is conducted with the means of a certain study content. This content is to be selected in such a manner as to provide "decomposition", i.e., the unraveling of mental processes in the solution of cognitive tasks and problems. The emphasis in the development of skills formed on the basis of the competence for cognitive modeling in education falls on cognitive tasks. For this reason, the educational process itself is interpreted as a process for the solution of educational tasks. This postulate underlies the model of situated constructivist learning as a sequence of study situations founded on the solution of cognitive tasks at a higher level. This will successfully realize the principles of situational constructivist education in which students and teachers act in a context where knowledge represent

mechanisms constructed within the moment of learning. Based on this analysis, it is possible to deduce the next condition for the use of infographics in the design of cognitive tasks in education, which enable the formation and development of modeling skills. This also poses another requirement as a condition for developing competence for cognitive modeling in education related to the structuring of cognitive information using infographics, which takes into account the building of personal meaning in mastering the study content based on a purposeful and systematic application of modeling in cognitive activities.

All this requires the design of a way to use infographics in the construction of cognitive tasks in education systematically in a manner that relates them to the formation of skills for the modeling of genus-species relations, cause-and-effect relations, regularities and abstractions to be used in the course of mental experiments of processes and phenomena from reality oriented towards their explanation.

Table 1. Groups of tasks for the development of skills for modeling through a systematic and purposeful use of infographics

Tasks groups [8]	**Specifications**	**Development of skills**	**Learning Outcomes according to the visual literacy competence standards [9]**
Modeling tasks (infographics)	These are tasks related to the presentation of a particular text (verbal model) in order to separate the essential features, properties and parameters of the described phenomenon and to highlight the key words underlying the design of the model.	Exploring the objects and revealing their essential properties; Systematizing and summarizing essential source information for the object under investigation in a mental, verbal, visual or other form; building the model;	Acquires and arranges images and output information; Identifies information relevant to the meaning of the image; Finds effective and efficiently accessible images and visual media; Evaluates the text information accompanying the images.
Tasks for transcoding information from one model to another (infographics)	A variety of models can lie at the basis of these tasks – graphic, symbolic, image schematic, etc. For instance, a graphically represented dependency is offered and the task is for students to be able to interpret these dependencies or a schema of some lab equipment is given and students are expected to answer questions on its functions and on the processes and experiments that can be conducted.	Systematizing and summarizing essential source information for the object under investigation in a mental, verbal, visual or other form; Coding, decoding and transcoding of information in and through models;	Defines and formulates the need for an image; Identifies information related to the meaning of the image; handles images in his/her cultural, social, and historical context; Affirms the interpretation and analysis of images through discourse with others; Appreciates the textual information accompanying the images.
Classification type tasks and modeling of definitional links and relationships	These tasks require classification by features.	Study of objects and revealing their essential attributes; Systematizing and summarizing essen-	Identifies different sources of images, materials and types; Identifies the physical,

		tial source information for the object under investigation in a mental, verbal, visual or other form; Model creation;	technical and design components of the image; Affirms the interpretation and analysis of images through discourse with others
Comparative tasks and modeling meaningful abstractions	These tasks are based on the comparison and selection of models in order to choose the one that best reflects a given situation. This improves students' ability to detect similarity and difference between the objects under comparison and the models that reflects them, to look for their causes, and to make deductions. Making comparisons is a matter of directly applying analysis, generalization, classification and analogy, which lie at the basis of modeling as an activity. The tasks for modeling abstraction are preeminently associated theoretical generalizations.	Selecting models (selecting the most appropriate for the particular situation); Practical and/or theoretical verification of the models;	Conducts effective image searches; Identifies the physical, technical and design components of the image; Affirms the interpretation and analysis of images through discourse with others
Generalization tasks for modeling genus-species relationships	They allow you simultaneously to check knowledge on more than one properties, signs, quantitative characteristics, conditions or regularity related to a particular object.	Study of objects and revealing their essential attributes; Systematizing and summarizing essential source information for the research object in a mental, verbal, visual or other form;	Identifies the physical, technical and design components of the image; Affirms the interpretation and analysis of images through discourse with others
Evaluation tasks and tasks for modeling cause-and-effect relationships	They are focused on one of the essential aspects of the learning process – the formation of assessment skills among students. Opportunities are given for revealing causality relations in the studied subjects, for their explanation and argumentation.	Practical and/or theoretical verification of the models; Coding, decoding and encoding information in and through models; Transfer of knowledge acquired for the model as knowledge of the subject under study.	Identifies information relevant to the meaning of the image; Evaluates the performance and reliability of images as visual communications; Evaluates aesthetic and technical features of images, evaluates textual information accompanying images; makes judgments about the reliability and accuracy of image sources

The following performance outcomes, corresponding to Standards 5 and 6 from the Visual Literacy Competency Standards framework [9], are related to the application of modeling and infographics as models in different contexts of the learning process,

i.e. they build up and create the conditions for developing competence for modeling through:

- Effective use of images and visual media for different purposes;
- Using technology effectively to work with images;
- Using problem solving, creativity, and experimentation to incorporate images into scholarly projects;
- Communicating effectively with and about images;
- Designing and producing visual materials for a range of projects and scholarly uses;
- Using design strategies and creativity in image and visual media production;
- Using a variety of tools and technologies to produce images and visual media.

4 Tools for rendering infographics

When making up an infographic, one must act creatively and strive that the result should meet some aesthetic standard. Infographic is not intended to entertain, but to convey a message. Several are the main steps that need to be taken in order to create infographics - monitoring, gathering information and data, analyzing these to identify the basic ones, setting goals (the messages), sketching the infographics, defining the best data visualization, application of color schemes and designs.

There are freely available online tools to help visually build an infographic. They can ease the process of creating, editing, and publishing informational graphics. Of course this is bound by some limitations, however, which can be considered insignificant to the need to automate, support and guide the creativity of students. Another option is to use some of the available standalone raster or vector imaging applications, but this will add further drawbacks due to the need to master this much more complicated tool.

The American Association of School Librarians has already honored some of these online tools for creating infographics through the years [10], such as PiktoChart (2016), Canva (2014) and Easelly (2013). Other similar tools are Infogram, Venngage and Visme. They provide a variety of templates, flexibility in arranging images and text, and some other functionalities, such as loading external graphical resources and teamwork. In Table 2, a comparison is made between the different platforms in terms of their functionality available without paid subscription.

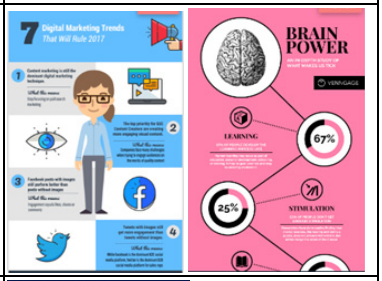
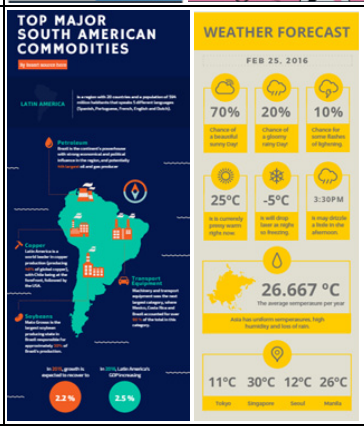
Table 2. Comparison of online infographics tools

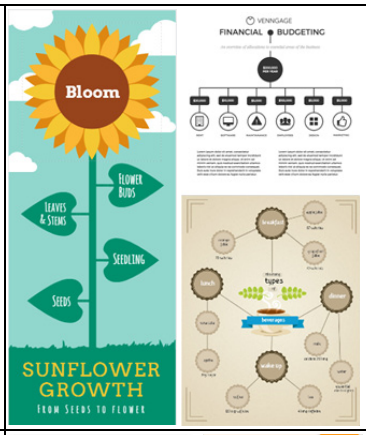
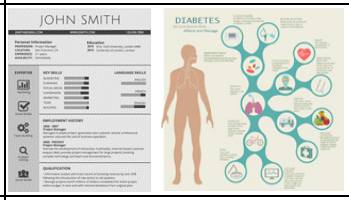
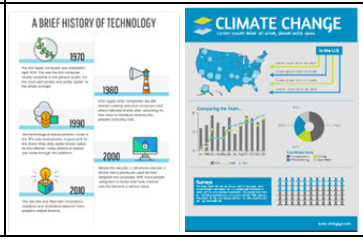
Online infographics tool / **Functionality**	**Easel.ly**	**Infogr.am**	**PiktoChart**	**Canva**	**Venngage**	**Visme**
Available visual elements: objects, icons, predefined blocks, shapes, charts, backgrounds, etc.	limited	limited	yes	yes	yes	yes

Availability of predefined infographics templates	limited	no	limited	yes	limited	limited
Flexibility in arranging elements of infographics	yes	limited	yes	yes	yes	yes
Import external graphics resources	yes	yes	yes	yes	yes	yes
Team or cooperative work	yes	no	no	yes	no	no
Export as image	low quality	no	low quality	no	no	low quality
Export as PDF (for printing)	no	no	no	no	no	no
Save into platform account	yes	yes	yes	yes	limited	yes
Save into cloud storage	no	no	no	no	no	no
Download project file	yes	no	no	no	no	no
Sharing	yes	yes	yes	yes	yes	yes
Embedding	yes	yes	no	yes	no	yes
Data import for charts	no	yes	yes	no	limited	yes

In fulfilling the tasks of implementing modeling by infographics, students should put together and combine artistry, critical thinking and technology. Yet, many platforms provide predefined templates and students can be advised to use specific infographics template depending on the particular type of task they need to complete.

Table 3. Matching tasks with an appropriate infographics templates

Tasks groups	Recommended infographics templates	Illustrative Example
Modeling tasks (infographics)	An appropriate template for this type of task is Informational infographic. Illustrate the object in the model (infographic) with an appropriate attractive image or headline text with large letters. Combine descriptions of its features into zones and systematize them.	
Tasks for transcoding information from one model to another (infographics)	Transcoding information is often used to emphasize the hidden connections. Rework statistical information by applying it to geographic maps, for example, or visualize the information through appropriate pictograms.	

Classification type tasks and modeling of definitional links and relationships	To create classification infographics, the appropriate templates are mind maps, timelines, or hierarchies. Time lines can reveal the definitional links when they are rather linear.	
Comparative tasks and modeling meaningful abstractions	One of the most powerful aspects of infographics is presenting comparisons. Most online platforms have separate template categories, namely for comparative infographics. Often, the design of the comparison infographic is divided into two zones, and the objects under comparison are described in the headings of the columns, and bellow them the corresponding parallels with descriptions are suggested. When the comparison is based on specific statistics, it is appropriate to include it as a chart.	
Generalization tasks for modelling genus-species relationships.	For the compilation of properties upon the presentation of the objects of modelling are suitable summary infographics. Hierarchical or mind-map infographics are suitable for genus-species relationships modelling.	
Evaluation tasks and tasks for modeling of casual links	Recommended infographics templates for this type of tasks are timelines or infographics that combine elements with maps and charts.	

5 Conclusion

In this paper, we motivate the application of infographics to develop skills for cognitive modeling in education. There is a clear opportunity that using infographics, we can develop a comprehensive system of cognitive tasks related to the formation of modeling skills and their adaptation to the development of visual literacy competence.

The six main groups of tasks set out a framework in which a number of specific tasks can be developed and applied in the learning process through the processes of adaptation and combination. Although a relatively new tool in the cognitive process, there are already suitable online tools to create infographics. Infographics have infiltrated our everyday life. This gives us reason to suppose that they will become one of the main means of natural visual assimilation of information. The use of modeling as a learning-cognitive method based on infographics should not be carried out by itself or in isolation but in the overall methodological context. This follows an integrated and integrative process, which in turn puts a number of requirements to the system of learning cognitive tasks and its synchronization with the other teaching methods used in the development of competence for cognitive modeling or other key personality competencies.

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