VISUALIZATION IN SCIENCE EDUCATION: THE RESULTS OF PILOT RESEARCH IN GRADE 10

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Abstract

The modern visualization is created to help in education processes and is oriented to the evaluation of knowledge. It is very important for science education to have perfectly prepared aids that could show invisible phenomena and could foster deeper motivation. The more images there are in education process the better pupils understand and realize information. This article encloses that visualization was popular in biology lessons and in physics, but teachers did not use computer based visualization and students did not use concept mapping in chemistry classes. Students had similar conditions to learn science in grade 10 and their opinion is generalized in the article.
Keywords: *science education, visualization*

Introduction

Modern technologies could be known as essential tools for education process. Visualization in science as an important teaching/learning tool has become of great importance nowadays because the technological progress is raising high requirements for education. According to B. Tversky (2005), the effectiveness of visualization derives from cognitively compelling mappings from real and conceptual elements and their spatial relations. It has been noted in research (Bilbokaitė, 2008) that visualization takes into account schoolchildren's perceptive and cognitive abilities including visual thinking and meta-cognition. Visualization also affects learning motivation and knowledge acquisition because clarity of information fosters schoolchildren's internal aim to find out about invisible phenomena and fix the acquired knowledge in a long-term memory; from there all learned things could be used for comprehension. In recent years visualization has become one of the most popular research objects in scientific research; many researchers (Barak, 2005; Sandvoss et al., 2003; Appling, 2004; Clark, 2004; Qian, 2006) have been working in this field. Computer based visualization is an important research field in empirical and logical sciences (Herráe, 2006; Mason, 2006; Wilder, Brinkerhoff, 2007; Toga, 2006; Podowski at al. 2006; Kohorst and Cox, 2007), mathematics (Giaqiunto, 2007; Nelses, 2001; Rivera, 2007), medicine (Rinner, 2006), engineering (Erol, 2001; Sampson, 2005). Many invisible phenomena that could not be seen in daily life or even looking through a microscope are found in natural science, which is a part of empirical and theoretical sciences; very puzzling for students science signs and models are not enough dealt with in secondary school. Many phenomena connected with formulas, equations, laboratory works are very difficult for schoolchildren and, as a rule, they lack knowledge in them. This supposes that misunderstanding in science and a lack of scientific literacy hinders learning motivation and interest in science.

The goal of the research is to find out what is the situation of visualization in the science education comparing data in sex aspect. Whether it helps to understand difficult levels of concepts or it does not? The main problem is that during education process students mostly use textbooks with 2D or 1D visualization that do not have any relations with 3D computer based visualization. The results will show the situation of visual representation in science education and will enclose the do these visualizations are helpful for students in learning process in grade 10.

Research Methodology

Theoretical background

The research is appealing to the *dual code* theory (Hodes, 1994). It is being proposed that visual and verbal information are interconnected by some contacts. Both kinds of information are connected in the consciousness, all this conditions the circumstantial perception of the object when a child encloses the visual part of the object and the verbal information encloses the side of the concepts. Visual system evidences in perception of knowledge where the spatial abilities, visual perception, encoding and transforming act. *Visual thinking theory* (Arnheim, 1998) ensures that visual thinking is one of the most important kinds of thinking in the human life. Information got in the images is more precise and the perception of it takes less time. Therefore, it is necessary to see as many views as it is possible and to develop visual thinking in order that conscious could get use to activate required processes of visual thinking needful for cognition. It is natural that visual thinking skills are essential for perception, comprehension, encoding, decoding and memorizing of those images. That is why assumption that good visual thinking skills condition perfect results in learning natural science. *L. M. Veker's* (1976) model of genetic structural intellect. According to Veker learning individual gains experience which is very important for other skills. Visual thinking is essential for later abilities to perceive information and to think in concepts. It means that visual thinking is a background for concept thinking. Especially it is meaningful in science education because mostly all phenomena are related with imagination and mental models in pupils' minds. There can be build the assumption that visual aids could help building original views that will be used to understand visual information and the verbal one in the future.

Instrument

The research instrument, a questionnaire with open-ended and closed questions, was designed. The questionnaire was composed well enough because internal validity was 0.6718 (Cronbach's alpha coefficient) and data should be reliable. The answers to the questions were ranked on a scale and the data were far from normal dispersion therefore a non-parametric statistical analysis was employed.

Participants and sample selection

107 schoolchildren from secondary schools participated in the research. Random sampling was chosen when schoolchildren in grades 10 had a possibility to participate in the research. It was important to identify the situation of computer based visualization in science education. These findings could be helpful for future research with a bigger sample. The questionnaire was used as a research instrument and distributed to grade 10 schoolchildren. All schoolchildren were from Šiauliai (Lithuania). There were 107 – from grade 10 in the sample. The respondents were about 16 years old. The respondents' distribution by gender: 72 girls and 45 boys of grade 10. The respondents belong to adolescent group (Beresnevičienė, 2003) thus they were able to evaluate the circumstances and a situation at school. This leads to an assumption that schoolchildren decided individually and chose the right answer to reflect a re-

al situation with responsibility. The second reason why schoolchildren of this age group were targeted is a science education program. All schoolchildren in grade 9 and grade 10 already had experience in using science concepts and could be sure about what they know well and what is still unclear.

Research methods

Theoretical: content analysis; Methods of data analysis: quantitative data: descriptive statistics, mean, standard deviation, percentages, index of popularity; non parametric statistics Mann-Whitney criterion.

Results of Research

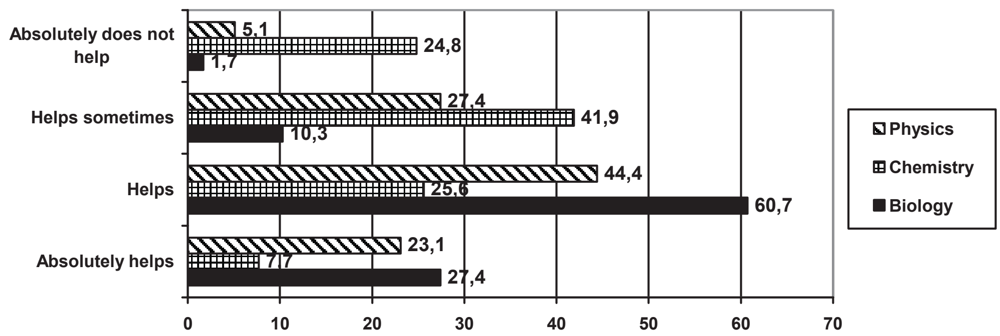

Figure 1. Help of textbook illustrations learning science concepts in grade 10.

We see that respondents' answers included different opinions (Figure 1). 27.4% of students agreed that illustrations in textbooks were absolutely helpful in learning biology. Also 60.7% of them agreed that visualization in textbooks helped them learn this discipline. In all 88.1% of students positively evaluated the help of illustrations in biology learning process. 23.1% of students understood that illustrations in physics textbooks were absolutely helpful in learning and 60.7% of them agreed that visualization helped them learn physics. It means that 67.5% of students thought that illustrations in textbooks helped them learn. Illustrations in chemistry textbooks were not as useful as illustrations discussed above. 7.7% of students thought that illustrations in chemistry textbooks were absolutely helpful and 25.8% of them agreed that illustrations were helpful. Data results show that illustrations in chemistry textbooks were least useful for students in learning chemistry.

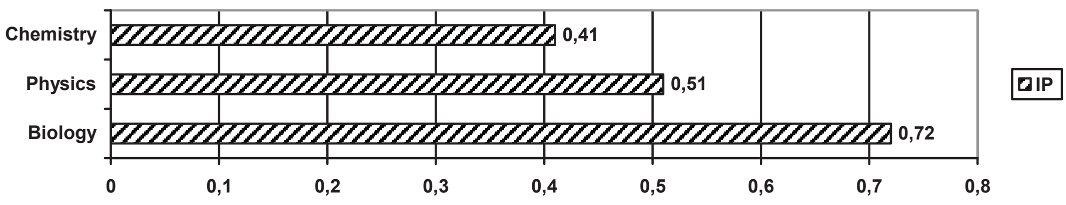

Figure 2. Help of illustrations in the learning process (grade 10).

Data analysis (Figure 2) shows that illustrations in science textbooks helped students learn biology (IP = 0.51) and physics (IP = 0.72). It means that illustrations in biology textbooks were clear and comprehensible, helped them understand invisible phenomena and learn concepts. For half of grade 10 respondents illustrations in physics textbooks were also useful, however, less than half of them noticed no help of them in chemistry textbooks.

Table 1. Comparison of illustrations' help in science education.

Proposition		N	IP	SD	Mean	t	df	p
Illustrations in textbooks help to learn themes in	*biology*	117	0.7139	0.21862	0.3270	10.529	116	***0.000***
	chemistry	117	0.3869	0.29779				
	biology	117	0.7139	0.21862	0.0951	3.079	116	***0.003***
	physics	117	0.6188	0.27895				
	chemistry	117	0.3869	0.29779	-0.2319	-6.799	116	***0.000***
	physics	117	0.6188	0.27895				

It can be assumed that visualization in biology textbooks is good enough and for more than half of respondents it was helpful in learning. Comparing answers on the usefulness of illustrations it was found out that illustrations in chemistry textbooks were less useful than visualized phenomena in biology textbooks (M = 0.3270, t = 10.529, df = 116, p = 0.000) and physics textbooks (M = 0.0951, t = 3.079, df = 116, p = 0.000) (Table 1). According to respondents, half of them were satisfied with illustrations in physics textbooks. Chemistry is the most difficult discipline and 2D visualization in textbooks was not helpful for grade 10 students. No statistically significant difference was found comparing the data by gender (see Appendix). This leads to an assumption that the analyzed situation could be typical for all population in terms of gender.

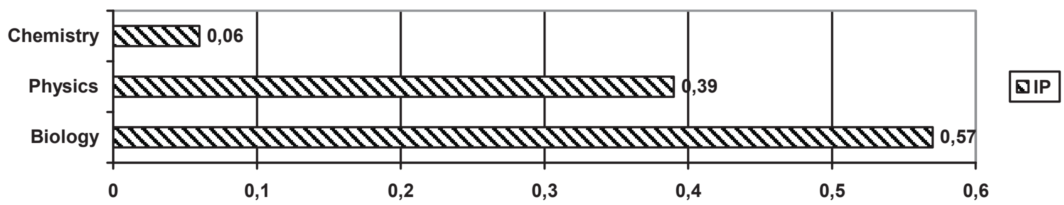

Figure 3. Use of computer based visualization in science disciplines (grade 10).

The popularity index includes the data on grades and shows the level of importance on the scale from 0 to 1. According to data analysis, computer based visualization was mostly used in biology classes (IP = 0.57) (Figure 3). Computer based visualization was also used in physics classes but less often than in biology classes (IP = 0.39). The data show that chemistry teachers mostly do not use computer based visualization in the education process (IP = 0.06).

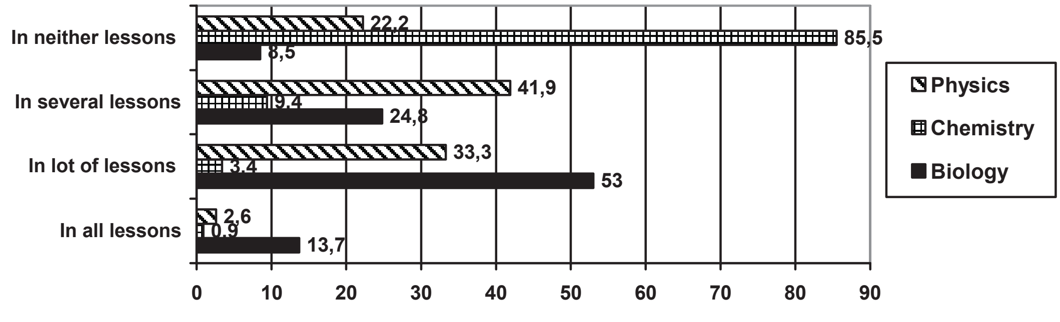

Figure 4. Use of computer based visualization in science disciplines (grade 10).

It was found out that 13.7% of respondents were sure that they were shown computer based visualization in all classes (Figure 4). 53% of students agreed that they had a possibility to see computer based visualization in many classes. This means that 66.7% of grade 10 students had opportunities to see visualized phenomena in many biology classes. Only 2.6% of respondents said that their physics teacher used computer based visualization in all classes and 33.3% of them were sure that computer based visualization was used in many classes. A different situation was identified in chemistry classes because

85.5% of students saw no computer based visualization in a single class. It may be assumed that grade 10 students had a possibility to learn from 3D objects in biology and sometimes in physics classes. Using Mann-Whitney criterion no statistically significant difference was found between opinions of boys and girls on this question (see Appendix).

Table 2. Visualization usage in science education.

Proposition		N	IP	SD	Mean	t	df	p
Teacher uses computer based visualization in the lessons of	*biology*	117	0.5728	0.27166	0.5097	16.022	115	***0.000***
	chemistry	117	0.0630	0.17527				
	biology	117	0.5736	0.27064	0.1864	7.302	115	***0.000***
	physics	117	0.3872	0.26756				
	chemistry	117	0.0630	0.17527	-0.3217	-10.706	115	***0.000***
	physics	117	0.3847	0.26741				

Comparing the answers on the use of computer based visualization three statistically significant differences were found (Table 2). Biology teachers used computer based visualization more often than physics teachers (M = 0.5097, t = 16.022, df = 115, p = 0.000) and more often than chemistry teachers (M = 0.1864, t = 7.302, df = 115, p = 0.000). These values are of statistically significant difference. Physics teachers used computer based visualization more often than chemistry teachers (M = -0.3217, t = -10.706, df = 115, p = 0.000) but less often compared with biology teachers and these differences are statistically significant. Chemistry teachers used computer based visualization least often in his context.

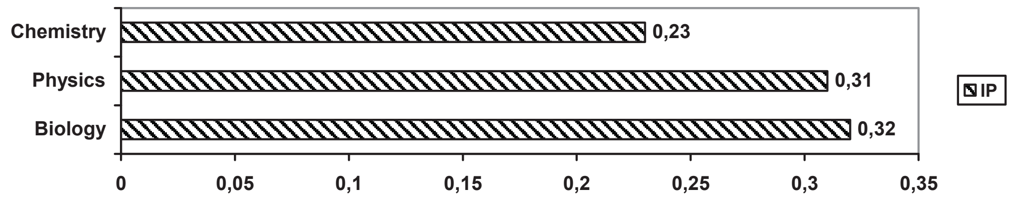

Figure 5. Use of a concept map in science disciplines in grade 10.

The data show that concept mapping was not popular in grade 10 (Figure 5). Students used concept mapping several times when they got much verbal information and wanted to schematize it clearly. Mostly students used concept mapping in biology (IP = 0.32) and physics (IP = 0.31) classes. Respondents used concept mapping in chemistry (IP = 0.23) classes very rarely.

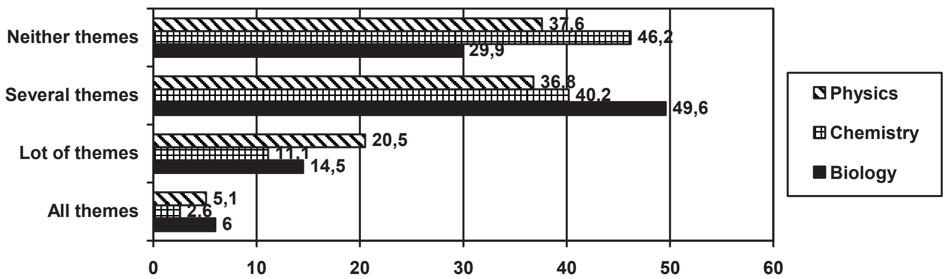

Figure 6. Use of concept mapping in science disciplines in grade 10 by themes.

According to the results, it is clear that 6% of respondents used concept mapping in all themes of biology, 14.5% of students did this in many themes (Figure 6). A very similar situation was identified in physics (5.1% of students agreed that they used concept mapping in all themes and 20.5 of them did it in many themes). Concept mapping was least used in chemistry classes: only 2.6% of students used it in all themes and 11.1% did it in many classes. Non parametric statistics shows that no statistically significant difference was found comparing the data in terms of gender (see Appendix). This means that both girls and boys thought they used concept mapping very rarely.

Table 3. Usage of concept map in science education.

Proposition		N	IP	SD	Mean	t	df	p
Makes an abstract in schemes of	*biology*	117	0.3208	0.27713	0.0881	3.382	116	***0.001***
	chemistry	117	0.2326	0.25632				
	biology	117	0.3208	0.27713	0.0108	0.396	116	0.693
	physics	117	0.3100	0.29671				
	chemistry	117	0.2326	0.25632	-0.0774	-3.001	116	***0.003***
	physics	117	0.3100	0.29671				

Comparing the answers on the use of concept mapping in science education two statistically significant differences were found (Table 3). Students used concept mapping in biology classes more often than in chemistry classes (M = 0.0881, t = 3.382, df = 116, p = 0.001) and this value is of statistically significant difference. Students also more often used concept mapping in physics classes than in chemistry classes (M = -0.0774, t = -3.001, df = 116, p = 0.003) and this result is of statistically significant difference. Speaking about the use of concept mapping in biology and physics classes, no statistically significant difference was noticed, the results were close to similar.

Conclusion

According to the data, it is clear that the environment for ten graders in biology classes was favorable because their teachers used computer based visualization frequently and students had possibilities to see 3D objects. These objects helped them learn difficult things. Illustrations in textbooks were useful both for both girls and boys. The most useful visualization was in biology and physics textbooks. Teachers did not use computer based visualization and students did not use concept mapping in chemistry classes. They sometimes used concept mapping in biology and physics classes. It is possible to say that students had better possibilities to learn biology and physics because visualization rather normal, in various forms and helpful in the learning process. No statistically significant difference in terms of gender was found, this shows that students had similar conditions to learn science in grade 10.

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Appendix

Table. Visualization usage in science education

Proposition	Boys			Girls			Mann-Whitney U	Z	p
	N	Mean Rank	Sum of Ranks	N	Mean Rank	Sum of Ranks			
Teacher of biology uses computer based visualization in the lessons	45	58,81	2646,50	72	59,12	4256,50	1611,500	-0,055	0,956
Teacher of chemistry uses computer based visualization in the lessons	45	62,56	2815,00	72	56,78	4088,00	1460,000	-0,948	0,343
Teacher of physics uses computer based visualization in the lessons	45	51,84	2333,00	72	63,47	4570,00	1298,000	-1,924	0,054
Makes an abstract in schemes of biology themes	45	59,20	2664,00	72	58,88	4239,00	1611,000	-0,055	0,956
Makes an abstract in schemes of chemistry themes	45	59,94	2697,50	72	58,41	4205,50	1577,500	-0,389	0,697
Makes an abstract in schemes of physics themes	45	56,43	2539,50	72	60,60	4363,50	1504,500	-0,690	0,490
Illustrations in biology textbooks help to learn themes	45	60,97	2743,50	72	57,77	4159,50	1531,500	-0,538	0,590
Illustrations in chemistry textbooks help to learn themes	45	62,69	2821,00	72	56,69	4082,00	1454,000	-1,017	0,309
Illustrations in physics textbooks help to learn themes	45	63,00	2835,00	72	56,50	4068,00	1440,000	-1,070	0,285

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