THE ROLE OF VIRTUAL WORLD IN EARLY SCIENCE EDUCATION

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Abstract

In the paper the process of implementation of computer animations and simulations within the early chemistry education and chemistry teachers training is described. The research project focusing on the pre-graduate chemistry teachers´ training in the field of ICT competences and on the learner’s ability to use simulation or real experiment is presented. The main problem appears in the meaningful application of computer animations and simulations in the phases of preparation, running and evaluation of the process of instruction. Authors provide crucial characteristics of both applications, learning activities suitable for implementation, quality criteria and didactic recommendations. The data were collected from the direct and indirect observation and the questionnaire, and they evoke discussions on problems of the virtual world, which is steadily been involved in everyday life of the developing society.

Key words

Early Chemistry Instruction; Pre-graduate Teachers´ Training; Computer Animations and Simulations.

Introduction

The feasible real experiment should not be in any way eliminated from school laboratory practice. This is the starting point of traditionally approaches to natural science curricula, and it is still in force. The real living environment makes us face more and more items of virtual environment, worlds, mediated by infinite possibilities of computer networks. The mediated perception through virtual images has become (thanks to massive spreading of information technologies) the major cognitive channel of school age pupils. Direct utilization of information from existing reality is steadily superseded and replaced by virtual information. How to blend an effective and meaningful application of real, indirect and simulative observation, measuring and experimenting according to didactic principles? (Bílek et al., 2009)

Current Challenges for Natural Science Education
The importance as well as the real meaning of natural sciences have often been defined by many a scientist, also viewed in a wider context of all human knowledge. Here we offer a few of these definitions (Dushl, 1990):

- All science should co-ordinate our experience and organize it into a logical system (A. Einstein).
- The challenge of sciences is to expand the fields of our experience and reduce the large fields of our presuppositions (N. Bohr).
- All science is composed of facts just as a house is made of stones. But a collection of mere facts does not make a Science and a heap of stones does not yet make a house (H. Poincaré).
- Science is the quest for knowledge, not the knowledge itself (D. Roller).

These quotations, with Roller’s utterance especially, show the targets and resources of science education and thus we may elicit today’s modern trends in science education.

The present reformation of curricula brings numerous challenges and demands. The society has been changing rapidly these days, and they are also to offer new definitions of targets and values in education. Educating in science needs to deal with the following complexity of problems in the near future:

- **Global issues and ecology problems.** Environmental issues have been in the centre of attention for the last 15 years everywhere in the world. Science education deals with latest issues of air pollution, global warming, ozone hole, de-forestation etc.

- **The relation between science and technology on one side and the society on the other side.** The credibility of science education has noticeably lowered. By results of the ROSE project (The Relevance of Science Education), having been carried out as a study comparing a sample of fifteen-year-old pupils in 40 countries all over the world, is a shiny example of the above mentioned feature of science education. The respondents to the quoted survey have not referred to science as of importance for life and future career. They also show no interest in becoming scientists in the future. The most positive attitudes to science education are from respondents in developing countries (Bangladesh, Uganda, Ghana). On the contrary, well developed countries (Japan, Great Britain, Denmark, Norway) prove a real dilapidation of science education (Bílek, 2005, Sjøberg, 2007).

- **Key words and basic conceptions.** As many foreign as well as domestic surveys show, it is highly necessary to reduce the content of what students learn within natural science classes. That is, speaking of the Czech Republic, especially the curriculum at the second grade of grammar schools, but also second grade of elementary schools. A major opportunity to reduce the amount of quantity is now being offered by curriculum reform. A new world-wide tendency in science teaching is to develop students’ competence as well as their ability to solve problems, all that at the expense of factual knowledge.

- **Inter-disciplinary thinking.** It is a way, or rather a strategy, enabling pupils to understand the meaning of curriculum in science education, especially if that is in context with everyday problems and issues.

It appears to be difficult to verbalize the targets and characteristics of today’s science education. The autonomy of teachers together with their responsibility are higher due to curriculum revision and world-wide tendencies in curriculum controlling. Modern trends and goals in science education could be described as follows:
• Re-definition of targets in science education. Targets are being gradually changed and also enlarged so that they reflect today’s development in technology, and mainly they reflect the needs of the society, nowadays necessarily conceived in its global connections.
• Basic science education ought to arise from the pupils’ interests, it also ought to respect and take advantage of their individual experience and concentrate on an immediate reflection of scientific findings in their life.
• Another aim or trend of modern science education mentioned is the reduction of the quantity of information to be learnt. Teaching sciences should cover a smaller number of topics. On the other hand, topics selected for the core of the curriculum ought to be studied thoroughly and more time should be allowed for these.
• Science education as framework for integrating subjects. Inter-disciplinary approach of today is mostly realized at primary schools (International Standard Classification of Education – ISCED1), it is less involved at lower levels of secondary education (ISCED2) and hardly at all at higher levels of secondary education (ISCED3). As it has been said earlier on, Czech teachers do not seem stirred by the current state of science education and they are reluctant to accept integration of ISCED2 and ISCED3 (Bílek and Králíček, 2007).

On a general basis it is to be said that science education ought to prepare pupils to use their knowledge acquired in science classes to improve their own living standards and to be capable of adapting to more advanced technologies used in everyday life (DeHart Hurd, 2002). J. Hassard (1999) defines science education to be the unifying element between sciences and the society. Science education is a branch based on discovering, evolving and analysing scientific work methods; it also is a quest for knowing as well as the knowledge acquired in this way. Reaching the above-mentioned targets in science education is classified to be the progress in so called science literacy. Virtual environment supported by ICT is penetrating both human and school life. All kinds of our activities can be supported by technologies. According to Marshall McLuhan (1964) it can be said “...technologies are enhancing our senses...” and they can support our understanding of nature and improving of our being.

Technologies Supporting the Essential Basis of Natural Science Education

Numerous authors, dealing with natural science education, rather intuitively tend to simple experiments (which do not require demanding material and technical equipment) to be made in the form of real activities; to remote observations and remote experiments to be used towards updating information and motivating, e.g. in the form of school project and project-oriented instruction; and to virtual experiments to be applied in interpretation of real experiments (simulators of laboratory activities, predicting and verifying results in experiments) and experiments which cannot be made in schools (dangerous, requiring demanding instruments, unobtainable, etc.). Forming and improving manual skills (measuring by available laboratory instruments, working with laboratory systems, even constructed from common subjects of everyday use, working with safe matters, etc.), which are substantial part of natural science education, cannot be fully replaced by practising through monitor and keyboard. On the other hand it is impossible to avoid indirect observations and working with models and instruments. Researching these fields leads, or not, to proving intuitive estimations, which is important, as well as answering other questions which result from this area of potential assets and threats. It is obvious that nowadays, in the period of creating and applying remote and especially virtual
laboratories and their accessibility also in extra-curricular conditions via Web, there is an increasing demand for new researches (mainly pedagogical and pedagogical-psychological ones) in this field.

In our research project we have proposed two main areas of objectives:

1) Analysis of results in research projects fully or partially dealing with effectiveness of blended real and simulative experiment in natural science instruction abroad.

2) Researching the effectiveness in application of selected simulative and animating experiments in early chemistry education.

The chemistry instruction will serve us as example of natural science instruction, as it corresponds to the team specialization. This subject provides wide space for application of information technologies supporting empirical (observation, measuring, experiment) and theoretical (modelling) cognitive methods. The technology development is very fast but as for its influence on learning in various stages of pupil’s development in the field of knowledge processing, there are only few applicable principles, rules and natural relations. Children’s concepts and likely learning styles are of some importance role in this process.

One of the main objectives is to express the role of modern technical equipment and technology in forming so called visual literacy, current and important part of which the work with computed simulations is. Modern technical equipment plays a contradictory role in this type of learning. On one hand, various processes and technologies of visualisation (mainly of 3-D objects) lead to using software products strengthening spatial skills, if properly used. On the other hand, both TV and computer screens may provide incorrect imaginations and habits, e.g. space less and other virtual experience which do not prove exact, but biased, misrepresented or incorrect forming of spatial skills, understanding weights, forces, energies, solidity, as well as emotions and feelings.

In the first part of the research project various proposals combining a real and virtual experiment were designed and considered by chemistry students and teachers who participated in the course Computer supported school chemical experiment and Chemical educational software (Bílek, Machková & Šimonová, 2011). Totally 78 university students of the 4th and 5th year evaluated four combinations below:

• simulation after real experiment for explaining its principle,
• simulation after real experiment for fixation knowledge,
• simulation before real experiment for explaining its principle,
• simulation before real experiment for training the activity.

Acid-base titrations, experiments with galvanic cells, measurements with spectrophotometer and pH-meter were used as examples. Most students preferred running the real experiment to the virtual one, and mainly using the simulation of experiment for explaining its principle. It was interesting that students did not consider the "training" role of simulations to be important for practising work with laboratory apparatus, understanding principles of laboratory procedures etc. (results see in Table 1).

In the second part of our research basic school pupils attend the laboratory and undergo pH measuring supported by real and virtual (simulated) apparatus, i.e. a virtual pH-meter, which is an available simulation on T. Greenbowe Web page (Greenbowe, 2009) and a hand pH-meter in real set on the laboratory desk.

Two as much as identical scenarios were prepared using either real or virtual pH-meter, managed by worksheets containing tasks of three levels:

**Level 1:** simple pH measuring in three samples of selected chemical matters (hydrochloric acid, sodium hydroxide and sodium chloride) in three different strengths.
Level 2: answers to problematic questions followed by their verifying by measuring changes in parameters of the matters (strength, volume, similar chemical matters), e.g. What pH value will a certain volume of hydrochloric acid solution reach having lower/higher strength than in previous measuring? How will pH sodium hydroxide with strength of 0.06 mol/dm$^3$ change when its volume increases from 100 ml to 150 ml? What pH value will potassium hydroxide solution reach in comparison to sodium hydroxide solution if the strength is the same? Etc.

Level 3: open task, e.g. Design and describe assignments and results of other tasks which you could do with the provided aids and real or virtual chemicals. You can ask your teacher to provide you with other chemicals and aids for the real experiment, or with advice on other functions of the simulated pH-meter for the virtual experiment.

### Table 1 Preferences of simulation/real experiment combinations

<table>
<thead>
<tr>
<th>Combination: I prefer to apply ...</th>
<th>Number of numerical orders according to the importance evaluation</th>
<th>Average order</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>1.</td>
<td>2.</td>
</tr>
<tr>
<td>Simulation before real experiment to train the activity</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Simulation before real experiment to explain its principle</td>
<td>23</td>
<td>24</td>
</tr>
<tr>
<td>Simulation after real experiment to fix knowledge</td>
<td>7</td>
<td>26</td>
</tr>
<tr>
<td>Simulation after real experiment to explain its principle</td>
<td>46</td>
<td>20</td>
</tr>
</tbody>
</table>

The following hypotheses were set for this research:

1) No statistically significant differences will appear in pupils’ results of pH-measuring in provided solutions of chemical matters with the real and simulated pH-meter.
2) No statistically significant differences will appear in pupils’ answers to problems questions dealing with pH-measuring in solutions of concrete chemical matters by the real and virtual pH-meter.
3) Pupils’ recommendations on using the laboratory arrangement for other measurements will be more frequent and varied, i.e. more proposals will appear, and the teacher will be asked more questions related to the real environment than to the virtual one.

The first and third hypotheses were statistically confirmed and the second one brings positive results for virtual environment (Bílek et al., 2010).
Conclusions and Discussion

Implementation of ICT to the process of instruction does not mean eliminating real school experiments from school laboratory practice. Real living environment makes us face more and more items of virtual environment, worlds, mediated by infinite possibilities of computer networks. The mediated perception through virtual images has become an important cognitive channel for pupils. Real information from existing reality is steadily replaced by virtual information.

How to blend an effective and meaningful application of real, indirect and simulative observation, measuring and experimenting according to didactic principles?

The ICT, especially their network systems, do not offer only advantages. They also bring risks and problems to teachers and pupils. Terms and conditions for the use of simulations and other computer support of empirical and theoretical cognitive methods, mainly the support of remote and virtual laboratories, are still in progress according to the growing possibilities of the Internet, Web services and possibilities of measuring, modelling and other means. Virtual universities, virtual classrooms or other ways of remote parts of educational systems in the field of natural science cannot work without the presented methodological components. At technical universities the remote and virtual laboratories have been common and we suppose that their spreading to lower levels of the educational system will not take a long time. In many cases they will be joint projects which should support interest in natural science and technical studies. In our opinion, the necessity to research this field, especially in situations where the initial relation to natural science and technical subjects is formed, is currently very topical and desirable. It is big motivation for continuing of our research project especially in the case of enlarging of respondents, examining next examples of virtual worlds (different animation and simulation in different didactical scenarios) etc.

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References


