ISSN 1512-1801

SPECIFIC REQUIREMENTS FOR CHEMICAL MULTIMEDIA AND THEIR APPLICATION FOR FORMATIVE EVALUATION

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Abstract.
The multimedia presentations are especially appropriate for blended e-learning in the traditional classroom; moreover, they can support the learning process in natural science classes. The nature of multimedia provides opportunities to present content in a more attractive and effective way and to provide meaningful interaction between teacher and student, among students and between students and the learning content. However, in order for a multimedia presentation to be effective, it should meet certain requirements. In the proposed paper such requirements are presented and discussed. The discussion is based on the literature outlining the principles of multimedia development with consideration of learning chemistry content in middle and high school settings using.

Keywords: *interactive multimedia, chemistry education, formative evaluation*

Introduction

For the chemists "All …is chemistry".

However, nowadays a lot of secondary students have difficulties in learning chemistry [1-3]. The reasons for these difficulties are various. One of them is related to the chemistry "triplet" – the three levels in chemistry – macroscopic, microscopic (submicroscopic) and symbolic level [4, 5]. They present a real obstacle for students, who have to observe and describe the process (macro-level), to explain the observations by the changes in micro-level and to present them using symbols related to the Latin names of the elements. Another problem is how to accommodate a chemistry education for citizenship; in other words, how to make this education relevant to the needs of all students. Finally, we need to provide adequate education both to these students who prepare for science/engineer chemistry carrier and for those who learn chemistry for science literacy [6]. An additional challenge which the contemporary schools face is the insufficient interaction between the students, between the student and the learning content, between the students and the teacher during the lessons. Active interaction seems to be often overlooked in the contemporary chemistry class because chemistry "is often taught as a collection of pre-determinant truths about which there can be no dispute" [6, p. v]. This can be very detrimental as it is well known that interaction supports active learning.

When the computer entered the classroom, teachers and educators hoped that it would be the solutions of their problems. Technologies did help to solve some of the existing problems but they also have raised new questions. Some of these new questions concern the new classroom environment, the equipment, the teacher competences, the selection of the most appropriate part of the content and activities for the e-learning. Also, the very important question about the quality of the computer applications used for learning and instruction has been raised. This last problem is very broad and in our work we present one specific solution for one case: multimedia presentation for the secondary chemistry classroom in face-to-face environments.

The main aim of this study is to develop requirements for chemistry multimedia presentations, which are the most frequent use of new technology in the chemistry teaching in Bulgaria. In order to develop and articulate the requirements we considered the main principles for chemistry multimedia as well as a comparative analysis between chemistry learning content and multimedia

ISSN 1512-1801

tools. In the development process of chemistry multimedia presentations we have considered the requirements system in formative evaluation.

Study Background

Multimedia principles for chemistry education

Multimedia principles and their theoretical bases are widely discussed from different point of view in The Cambridge Handbook of Multimedia Learning. In his overview of current research, Mayer outlines the main principles to be considered when multimedia is included in the learning process; more specifically he defines main principles of the *design of multimedia learning environment* and advanced principles of *multimedia learning*. He approaches the issue from a cognitive position considering the dynamics of content perception and the mechanisms of learning [7]. Further, Morreno [8] presents ten main multimedia design principles derived from a cognitive-affective theory of learning with multimedia: multimedia, modality, redundancy, temporal contiguity, spatial contiguity/split attention, coherence, personalization, guidance, interactivity, reflection.

According to Kozma and Russell [9, p.410] the following principles should guide the development of chemistry educational multimedia:

- Multimedia principle: "Learning from words and pictures results in deeper learning than learning from words alone."
- Contiguity principle: "People learn more deeply when corresponding words and pictures are presented near rather than far from one another in space or time."
- Modality principle: "People learn more deeply from animation and narration rather than animation and on-screen text."
- Signaling principle: "People learn more deeply when guidance is provided for directing the learner's attention."
- Interactivity principle: "People learn more deeply when they can control the order and pace of presentation."

These principles are used in our study to develop requirements for formative or summative evaluation of chemistry multimedia presentations.

Chemistry Learning Content and Multimedia Tools

In addition to the literature research on principles for development of effective science applications, we have also analysed the relationships between the chemistry learning content and the tools in multimedia presentations. The main analysis purpose was bringing out the most relevant tools for the presentation of chemistry content. For analysis purposes the chemistry content is divided in two main parts: information about chemical objects – (1) substances and processes; (2) information about specific chemical activities. The main tools in multimedia presentation are: text, sound, still objects (as still graphics, images, models, photographs), animated objects (as animated graphics and models), video and hyperlinks. [10, 11]

Figures 1 and 2 illustrate the results of our analysis of the multimedia tools, and outline the most adequate ones in presenting the information of chemistry objects and specific chemical actions in the curricula. For example, video-clips, still and animated objects are the most appropriated tools for presentation of the facts about the substances' properties.

ISSN 1512-1801

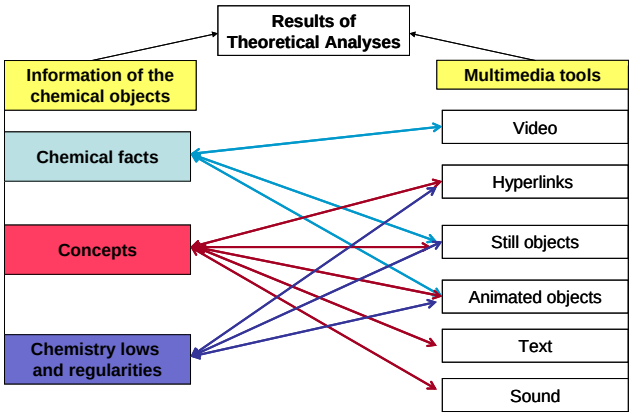

Figure 1. Chemistry learning content and multimedia tools: theoretical analysis results of the information of chemical objects

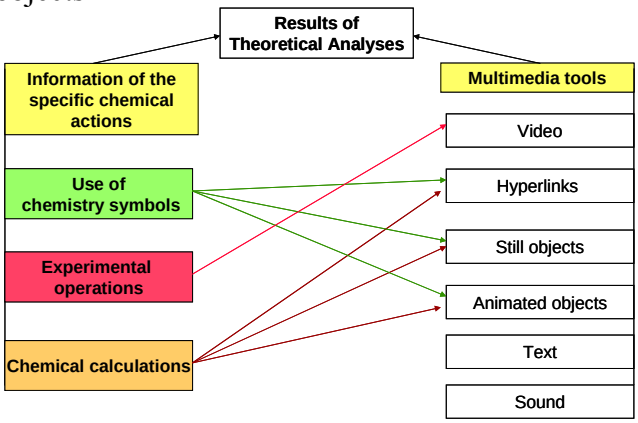

Figure 2. Chemistry learning content and multimedia tools: theoretical analysis results of the information of specific chemical actions

Requirements for Chemistry Multimedia Presentations

Based on the principles mentioned above as well as on the presented analysis results we have developed requirements for chemical multimedia presentations which can be organized in four groups:

1. The multimedia presentation's objectives of and their correspondence to national standards;
2. The chemistry learning content: general requirements, specific requirements depending on the contents;
3. Interaction with the user (student or teacher);
4. Technical aspects and screen design.

The second group, concerning chemistry learning content in the presentations, is divided in general and specific requirements. The first subgroup (general requirements) is related to the scientific correctness and to some of the multimedia development principles. The second subgroup is based on other principles of multimedia design and on the results of the theoretical analysis. The third group includes some requirements about navigation in the multimedia presentation when used by the teacher in the traditional classroom. The requirements of the third group also require different tasks and learners' activities and means for their support in the presentation. Further in this article we represent two examples:

1. The specific requirements, which belong to the second subgroup and are oriented to the presentation of chemical substances:

- The multimedia presentation includes:
  - Photographs or video of the appearance of substances

ISSN 1512-1801

  - Representation of substance structure by a combination of means – photos, 2D and 3D models, structural formulas
  - Representation of substance application by photos, schemes, video
  - Representation of the physical and chemical substance properties by a combination of means – photos, video, still or animated models, tables, graphs, chemical equations.

2. The requirements of the third group concern the opportunities, which the presentation provides for two kinds of interactions: between the presentation and the user (teacher or student); between the learner and learning content. These requirements are:

- The multimedia presentation includes:
  - List of topics addressed in the presentation hyperlinked with corresponding parts of the presentation
  - Hyperlinks between parts of the presentation, which are conceptually related
  - Appropriate tasks and activities for the students, oriented to rationalizing and learning
  - Users' guides for the teacher and the students
- The tasks support students' engagement and motivation by involving them in appropriate activities and creating connections with practice
- The tasks and their solutions are represented by separate fragments: the task content, help, and solutions. This creates opportunities for self-dependent student activities.

The Application of the System of Requirements

The creation of multimedia presentations takes much time. If only a summative evaluation is applied at the end of the presentation development process the necessary subsequent repairs might be an expensive and long process. This suggests that applying the system of requirements for formative evaluation not at the end but in the process of multimedia presentation development would significantly support the development process. Therefore, the formative evaluation has given us the opportunity to:

- Clarify the presentation's goals according to national standards
- Establish the most appropriate multimedia visualization for the specific learning content
- Create tasks, supportive feedbacks and helps
- Connect the academic content with its practical importance
- Provide presentation's application in deferent lesson's situations by useful navigation

Based on the formative evaluation we have developed three interactive multimedia presentations about learning content of Group II in the Periodic table. These presentations are for teaching the chemical elements following the deductive approach. This approach was chosen because the students have already studied the periodic law and the trends in the Periodic table and they are able to apply specific knowledge.

According to the requirements from the second group, the presentations include different modes for substances representing, which are complementary to one another: photos, models, video and symbols. Considering the third group of the requirements for chemical multimedia presentations (interaction with the user) a number of tasks for students are included in the presentations. The tasks' solutions would be provided in stages – using the click effects – as a specific support for students. The developed multimedia presentations have been piloted in actual chemistry lessons. The observations have shown that they are well received by both teachers and students.

ISSN 1512-1801

Further Study

The article presented a system of requirements that has been developed on a theoretical basis. Guided by this system, specific multimedia presentations have been developed and piloted in the actual chemistry classes, observations were made in order to detect the initial response of the participants from both groups – learners and teachers. As mentioned above, these initial presentations were received well. The next step we are planning to undertake is to conduct an expert evaluation; we believe that experts will be able to pinpoint missing elements or ones that are not necessary, they can evaluate each criterion and make suggestions for addition of other ones.

In conclusion, we believe that these requirements will provide useful guidance to teachers and developers of multimedia products. They can be used also for summative evaluation of existing interactive chemistry lessons available on The National Bulgarian Educational Portal. Thus, keeping the principles in mind, the teachers may take more informed decisions about the quality and the appropriateness of the ready-to-use e-materials available online. In addition, teachers frequently develop their own presentations in order to meet the need of their students; this specific system of requirements will allow them to improve their presentations.

Acknowledgement: This study is funded by Project “Integral University Center for Research, Design and Delivery of Quality e-Learning in Diverse Contexts” (2009-2011) project number: INZ01/0111, funded by the Bulgarian National Science Fund.

ISSN 1512-1801

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Amount of figures - 2

Article received: 2011-12-24