ABSTRACT:

Even an excellent chemistry (or science) teacher cannot teach the subject by oral lectures only. It is highly desirable to support the teaching process using suitable teaching aids, whether real or virtual, which better and more clearly demonstrate the aspects of the subject to be taught, especially with regard to the conceptual parts of the curriculum. It is also necessary to supplement the teaching of science subjects with demonstrations of the taught themes and/or phenomena, from various analogies to the real experiments. Unfortunately, due to the limited possibilities of schools, the availability of the teaching aids is very limited. In addition to that, the implementation of laboratory courses is further complicated by obstacles associated with safety issues and/or rules of storage of chemicals. However, the appropriately presented experiment is often crucial not only for the understanding of the given chemical problem, but may also possess the motivational and formative character for the pupils. The pupils acquire non-distorted attitudes and opinions during the (proper) laboratory work and/or appropriate employment of illustrative teaching aids, which is important not only for his personal development but also for the society, he is part of. Support of the implementation of the experimental activities in schools and appropriate utilization of suitable and illustrative teaching aids is therefore crucial for education in the field of science subjects as well as chemistry. These teaching aids for chemistry education may not only include physical learning models that are most commonly used in chemistry education. For example, many real experiments are not sufficiently illustrative as these experiments are taking place too quickly or slowly or they are just too small and important aspects of these experiments are not visible. In such situations, virtual teaching aids in forms of videos, simulations or animations can be helpful to support the teaching process. It is therefore necessary to research, design and create such tools to visualize originally invisible aspects of the experiments. Unfortunately, high quality teaching aids are generally deficient in Czech schools, hence, creation of suitable and high quality illustrative teaching aids, whether virtual or (physically) real, is necessary.

Based on necessity and lack of teaching aids (real as well as virtual), the Ph.D. theses were focused on design, production and testing of new, modern and illustrative teaching aids for chemistry education. The first type of such aids were virtual aids in the form of digitized experiments (video records of chemistry experiments). With respect to that, the records of most interesting experiments of ca 40 basic chemistry elements were made and published. The records demonstrate otherwise invisible or obscure, but important, aspects of the experiments which are not usually observable doing real experiments. The records were made using “special” filmmaking techniques (high speed camera, time-lapse, macro) and are made with respect to achieve the best technical quality as possible according to used equipment. The Ph.D. thesis also discusses the aspects of employment of the “special” filmmaking techniques for production of records of chemistry experiments and best experience to prepare the educational and illustrative records. Using the videos, a new webpage focused on selected properties and characteristics of the selected elements of periodic system of elements (PSE) has been made, as the records of chemistry

experiments are integral part of information related to the elements in PSE. The elements are presented in the form of PSE (long version) which acts as unifying element of the webpage.

In the second part, the Ph.D. thesis deal with exploration of the possibilities of utilization of additive manufacturing, in particular of 3D printing, for a production of illustrative teaching aids for chemistry education. In the framework of these Ph.D. thesis, ways and general procedures for production of various models by 3D printing were tested and discussed. The procedures consist of all the steps of the process, hence, design of 3D model and its treatment for 3D printing, refinement of printing parameters and printing of physical models and their post-processing. With respect to this part, 3D models of 3D periodic tables, atomic orbitals, various proteins and functional parts of some devices were designed, printed and tested. These models were published on the Internet as part of the 3D distribution database thingieverse.com, where they found a large group of their supporters and were rated positively by their respective users.

Evaluation of produced records of chemical experiments through statistical analysis of questionnaire research showed that the pupils participating the research indicated very positive attitudes and opinions to the presented videos (the evaluation of overall satisfaction showed a value of median as 6 on the 7 point Lickert scale). The results also showed increase the intrinsic motivational orientation of the participating pupils after watching the selected videos. Therefore, the results of the Ph.D. thesis indicate that both types of teaching aids produced in the framework of the Ph.D. thesis, video records of chemistry experiments as well as 3D models produced by 3D printing, can be very useful aids in chemistry education at all types of schools in the Czech Republic.

KEY WORDS

video-experiment, chemistry education, recording of chemistry experiments, unusual approaches, teaching aid, 3D printing