Design of Educational Videos for University Entrants Regarding the Topic "Acids and Bases"

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Abstract

In this contribution, we'll present a project for university freshmen with chemistry as either their major or minor. The project's aim is the design of didactically sound educational videos supplying students with solution strategies regarding exercises in the subject area of acids and bases. To ensure sustainable learning successes, special focus is placed on students' individual prior experiences as well as their proficiency levels [1].

For this purpose, specific approaches for several individual exercises are being presented in the form of narrated step-by-step instructions, using the presentation medium PowerPoint. Within the videos a strong emphasize is put on the macroscopic, submicroscopic and representative dimensions as described by Johnstone's triangle, in order to substantiate the students' chemical understanding [2]. To this end, the videos are being supplemented by a number of descriptive graphics and experimental sequences.

The chosen medium offers numerous advantages: (i) a location-independent play-back, (ii) an unlimited number of re-runs, (iii) the addressing of several learning channels such as visual and auditory senses, (iv) an increased learners' motivation due to the interactive character, and (v) the cultivation of learning skills such as autonomous learning and knowledge expansion. Thus, conceptual gaps and misconceptions should be overcome and a more successful start into chemistry studies should be achieved [3,4]. The educational videos will cover most of the topic's important elements such as the theories and the strength of acids and bases, pH calculations, dissociation constants and ionic products, buffers, as well as neutralizations and volumetric analyses.

1. Introduction

Today's students belong to the generation of "Digital Natives". This term refers to a group of young adults who are very experienced in handling modern technologies as they have grown up in a highly technologized environment [5]. Computer games, emails, the internet and smart phones are essential parts of their daily lives [6]. Additionally, more than two-thirds of the students use online resources for educational purposes or for general research [7]. Thus, this trend has also made its way into educational institutions such as universities. Online-supported learning, for instance, has led to a greater variation of courses and, therefore, to a greater audience thanks to the easier access to educational opportunities offered by universities [8].

The increasing number of students is accompanied by a greater level of heterogeneity in their respective levels of specific content knowledge. Most students lack fundamental knowledge regarding general chemical principles and concepts [9]. These missing capabilities in acquiring the required content knowledge have negative effects on their academic success. Tallmagde and Chitester identified six areas of potential difficulties: atomic structures, chemical bonding, intermolecular forces, redox equations, solutions as well as acid-base reactions [10].

Additional services such as tutorials offered by universities to close the knowledge gaps are reasonable, however most of the time they cannot be fully utilized by the students because of low adaptability to the rather restrictive schedules. A potential solution to this problem is the provision of educational videos on a suitable platform. This is an effective way to support students in gaining control of their studies and at the same time to encourage their independence.

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The key advantage of educational videos over traditional teaching methods is that the learning material can be repeated indefinitely until the core aspects are fully understood. Furthermore, initial empirical evidence for the effectiveness of educational videos exists: a study in a course for analytical chemistry showed a significant rise of the examination results of low and average performing students after watching educational videos in the second year of their studies [11]. Mayer's Cognitive Theory of Multimedia Learning additionally states that the simultaneous presentation of verbal and visual material, as realized in videos, is the most effective solution for beginners and visual-style learners [12].

2. Task-Based Video Tutorials in Chemistry Education

The aim of the entire project "Task-based Video Tutorials in Chemistry Education" is to provide so-called sets consisting of exercises and supplementary educational videos respectively providing step-by-step solutions. Based on the study of Tallmagde and Chitester the sub-project described in this contribution aims to design educational video tutorials for the topic acids and bases. The topic contains the theories by Arrhenius as well as Brønstedt and Lowry, the strength of acids and bases, pH calculations, dissociation constants and ionic products, buffers, as well as neutralizations and volumetric analyses.

The general structure of the videos is depicted in Figure 1 below. Following the presentation of the task, the corresponding video of the experiment is shown. Afterwards, the mathematical description with an overview over the sub-steps is given. These are explained intensively in the step that follows. Finally, the results are being displayed.

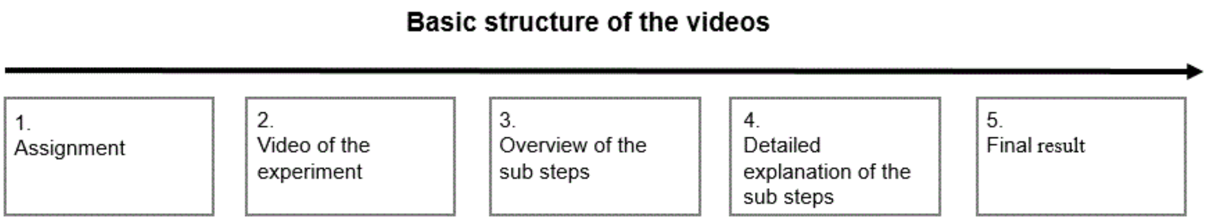

Fig. 1: General structure of the educational videos.

During the development of the educational videos, special attention was placed on general aspects such as the content of the videos, the knowledge to be conveyed, the choice of images and the length of the videos [13]. For didactical purposes the length of the videos does not exceed the duration of ten minutes, taking the audience's attention span into account [14]. Based on the multimedia design principles by *Mayer*, several aspects were taken into account during the didactical conception of the videos, such as avoiding irrelevant contents in order to minimize the cognitive load, highlighting important information to draw the students' attention to critical elements, avoiding redundant material such as additional subtitles for the audio contents, keeping related pieces of information (e.g. descriptions and graphics) together and therefore presenting audio commentary and slides simultaneously [15].

The explanations in the videos follow a deductive procedure. Based on the task the respective basic principles and formulas of the symbolic level are being introduced. Subsequently, a transfer to a specific example follows. Finally, the symbolic level is linked to the macroscopic level. For the design of the videos we therefore made sure to include all three levels of representation in Chemistry (macroscopic, submicroscopic, symbolic) [16]. Especially the transition between these levels is important for a comprehensive understanding of chemical contexts [17].

In the beginning of the videos the macroscopic level is being presented using short video clips of the experiment. In the next step, the submicroscopic level of the phenomenon is being visualized via graphics. The connection between the submicroscopic and symbolic level is being achieved by using correlating colour designs as presented in Figure 2.

In order to draw the attention to the chemical context, a simple colour design was chosen. The step-by-step explanations ensure more transparency and traceability. Respectively coloured frames clearly differentiate basic concepts and formula from specific examples or results.

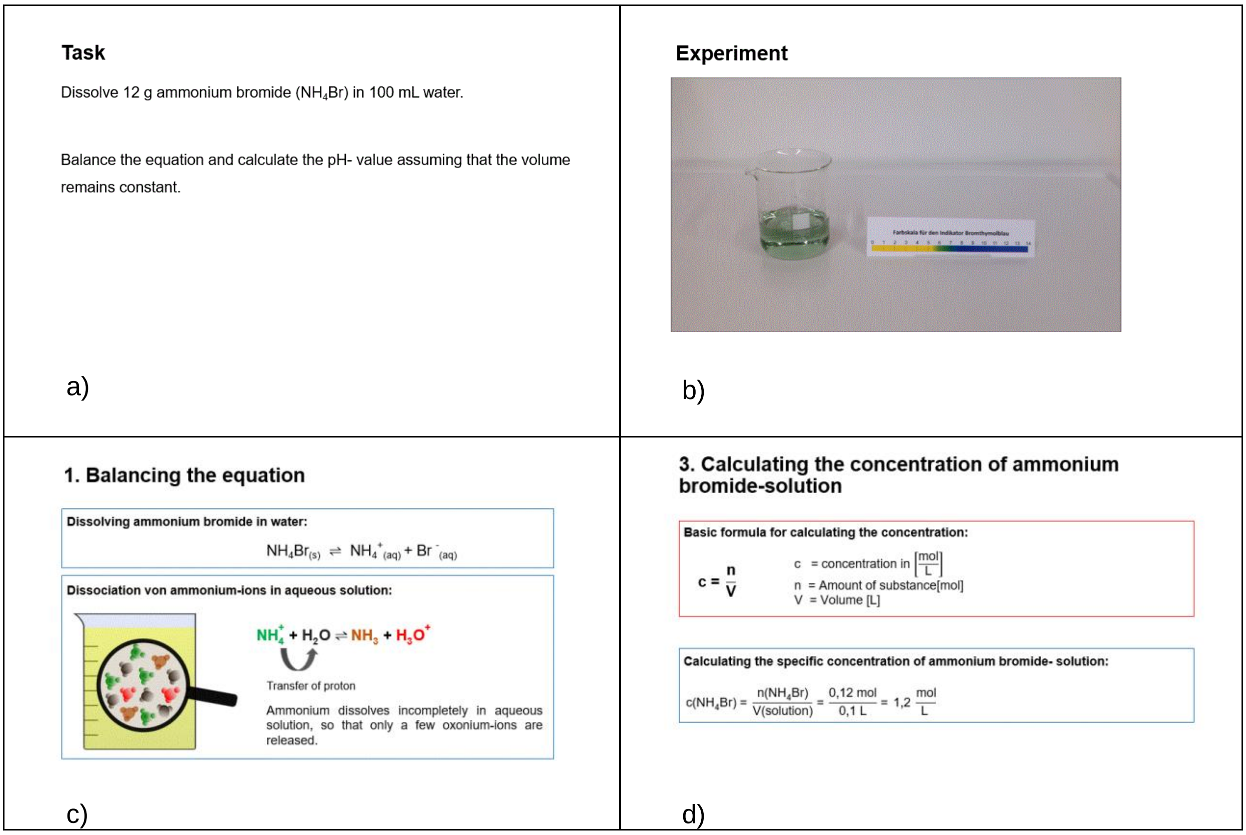

Fig. 2: Scenes from the educational video “pH-value determination of an ammonium bromide-solution.” a) Task b) experimental video c) and d) explanation of the sub-steps with diagrams.

3. Options for Implementation

The sets consisting of the training exercises and the corresponding videos can be implemented in the context of the “Inverted Classroom” – method. This method is based on the exchange of traditional activities in- and outside the lecture hall: “Inverting the classroom means that events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa“ [18].

This means that the independent study of the content takes place at home supported by online material. The students decide individually which contents they want to study, proceed at their own pace and choose their own learning strategies. In-class lectures can be used to ask questions, to eliminate uncertainties or to deepen the contents efficiently. The success of Inverted Classroom environments has also been empirically proven: students who participated in the Inverted Classroom approach achieved significantly better results in projects and exams [19].

Furthermore, educational videos can be consulted by the students in all stages of their educational career paths, e.g. in the beginning of the term to close the existing knowledge gaps, to practice and deepen their knowledge during the semester or as a control tool during exam preparation. At the same time the self-sufficiency of the students can be encouraged when independently studying with the help of the videos at home.

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