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END OF PROJECT REPORT:

Development and Evaluation of an Interactive Screen Experiment about Acid-Base Strength

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Recently, it has become apparent in chemistry education that, in addition to hands-on experiments, simulations and interactive screen experiments (ISEs) are useful and necessary, especially with experiments students cannot conduct safely at their homes. Whereas numerous simulations, particle models and instructions for experiments exist, there has been a minor focus on combining the two. Our project aims at constructing and evaluating such a combination by designing an ISE based on an acid-base experiment and integrating a 'magnifying glass' simulating the reactions occurring on the particle level. We intend to so by designing mobile apps and a WebApp of the ISE and evaluating its functionality both by questionnaire and eye tracking.

As stated in the exposé, simulations and interactive screen experiments (ISEs) constitute not only a feasible but in many cases also an essential alternative to hands-on experiments, e.g., in cases where the real-world experiment is too dangerous or cost-intensive to set up. In other situations, simulations and ISEs offer additional information such as a modelling of the particle – or submicroscopic – level so as to better explain and understand a phenomenon or reaction.

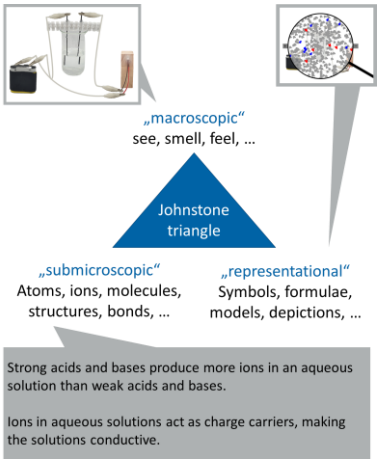

Figure 1. Underlying assumptions for the development of the app, i.e., explaining macroscopic properties of acidic and basic solutions on the submicroscopic level and modelling them on the representational level (Johnstone, 2000; Taber, 2013).

In the case of the project, we aimed at combining a rather simple experiment with such a model (Lancaster et al., 2021; Watson et al., 2020) in the form of an app (WebApp and smartphone app). Overall, we intended to design and evaluate an interactive screen experiment which includes aspects of a computer simulation whilst focussing on the topic of acid-base reactions and acid/base strength (cf. Fig. 1). the topic constitutes an essential part of chemistry curriculum and as such represents an important part of the Austrian curriculum for upper secondary school (BMUK, 2016); however, is not explicitly stated in the corresponding Czech curriculum (RVP G, 2007). Overall, the app should illustrate the connection between acid and base strength and degree of ionisation in aqueous solutions leading to different conductibility of the solutions. Additionally, the app should offer an insight into the submicroscopic make-up of the solutions so as to understand underlying reaction mechanisms and processes.

Figure 2. The cooperation partners and project structure.

In order to do so, the project relied on cooperation between three institutions: the Faculty of Education at Charles University, Prague (PhDr. Martin Rusek, Ph.D.,), the Austrian Educational Competence Centre Chemistry at the University of Vienna (Mag. Rita Krebs, BA) and the HTL Wr. Neustadt, a vocational school in Lower Austria (Mag. Markus Reis, BEd; Elvin Sabani, Christoph Schefbänker, Samuel Nagy). Whereas the researchers from the universities provided the subject-specific and methodological input, the IT teacher Markus Reis offered his expertise in programming to the project. The programming of the app itself was undertaken by three students at the HTL under the supervision of Markus Reis and Rita Krebs, as the completion of a complex project such as this one is part of their school-leaving examination (OeAD, 2022).

The following steps were undertaken by the project partners in the course of the project:

- Preliminary meetings amongst the project partners to define the scope, time frame and cost of the project,
- deciding on the topic of acid-base reactions and the experiment (highlighting acid/base strength via a solution's conductivity),
- programming the backend architecture of the app on Firebase,
- specifying the content of the app and its possible uses,
- designing its frontend architecture and including the digitalised experiment and a 'magnifying glass' modelling the submicroscopic level,
- releasing the app in the iOs and Play Store and on the webpage www.chemsim.eu/,

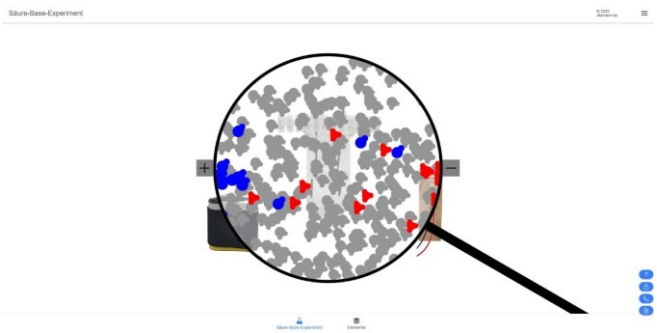

Figure 3. The 'magnifying glass' depicting our visualisation of distilled water *at the submicroscopic level.*

- evaluating the app (on-going), and
- researching and discussing other possible functions of the app (on-going).

As seen above, after the preliminary meetings on whether the project itself would be feasible, Martin Rusek and Rita Krebs discussed the app's content and made considerations about its educational use. The backend programming was conducted mostly independently by the students parallel to these discussions. Following Rita's visit to the University of Prague from 26/10/2022 to 4/11/2022, we decided on a simple app design that included a start screen, the possibility to set up the virtual experiment, and an options menu in which labelling, the 'magnifying glass', and a barrier-reduced version of the app can be selected, and the user can switch between English and German.

During the on-site visit, two workshops were conducted: *Visualisation of the submicroscopic level* Martin and *App Development* by Rita. The aim of these workshops was to discuss the app design and development process, clarify its content and discuss future additions as, at this point, only one experiment could be 'conducted' in the app, but others would also be interesting. Finally, the app prototypes went live at the end of 2022. In order to evaluate the Apps' usability and functionality, university students of chemistry education at the University of Vienna are currently being surveyed with the use of a questionnaire (Brooke, 1995, 2013; Leppink et al., 2013). (Johnstone, 2000; Taber, 2013)

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