"CSI VIENNA" – DESIGN AND EVALUATION OF THE OUT-OF-SCHOOL LAB *ELKE*

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Abstract. *In the course of PISA and TIMSS a lot of out-of-school lab days have been established; as non-formal extracurricular learning environments they shall provide an efficient addition to formal learning at school. The ELKE project is a non-formal extracurricular learning lab that aims at linking curricular content and competence-centred activities. This makes it an effective addition to chemistry education at school. Additionally, ELKE is a teaching/learning-environment for university teacher training. The poster illustrates the general concept as well as the contextual design of "CSI Vienna", the Viennese experimentation day. Furthermore, it shows first results concerning the effectiveness of the ELKE student lab on learning. These results will also be related to the outcomes of studies on ELKE as a teaching/learning-environment for future chemistry teachers.*

Key words: Out-of-School Lab Days, Competence Orientation, Teaching and Learning Chemistry

OUT-OF-SCHOOL LAB DAYS – THE CONCEPT OF *ELKE*

Out-of-school labs are unquestionably an enrichment to regular formal learning environments (e.g. Itzek–Greulich et al., 2017; Bell et al., 2003). Particularly the activity-oriented approach of many out-of-school labs allows students to acquire knowledge and competences in various contexts and consequently develop scientific literacy. In order to achieve optimal learning gains from these non-formal learning environments, however, it is necessary to connect them with the formal in-school learning environment. Itzek-Greulich et al. (2017) showed that linking out-of-school lab days and school had a positive effect on the development of students' content knowledge. With particular regard to scientific literacy and acquisition of scientific competences Rehm & Parchmann (2015) claim that a reasonable and systematic interconnectedness of these types of learning environments is crucial to ensure optimal learning outcomes. Therefore, it has to be examined how non-formal learning environments like out-of-school lab days can contribute to establish a link to the formal learning environment of school.

The extracurricular learning lab *ELKE* systematically connects formal and non-formal learning environments, providing benefits for students as well as pre-service chemistry teachers by combining a classical student learning lab and a teaching/learning lab (Groß & Schumacher, 2018). The German acronym *ELKE* stands for experimenting (German: 'Experimentieren'), learning (German: 'Lernen') and acquiring competences (German: 'Kompetenzen Erwerben'). Integrating these principles into the out-of-school lab experience and dealing with content that is aligned to the respective governmental curriculum, which can be prepared and revisited by teachers in school lessons, *ELKE* successfully establishes the connection between a non-formal learning environment and regular chemistry teaching at school. In order to be able to do so, materials that teachers can use for preparation and follow-up activities during their lessons are provided.

As a classical student learning lab *ELKE* offers a student-centered and competence-oriented design. Aiming at increasing the scientific interest and curiosity of the students participating in the program, each *ELKE* day is embedded in a context that school students might find interesting; by taking new roles (like being a scientist or criminal investigator)

Gross, K. & Harmer, S. P. (2020). "CSI VIENNA" – Design and Evaluation of the Out-Of-School Lab ELKE. In M. Ludwig, S. Jablonski, A. Caldeira, & A. Moura (Eds.), *Research on Outdoor STEM Education in the digiTal Age. Proceedings of the ROSETA Online Conference in June 2020* (pp. 205-208). Münster: WTM. https://doi.org/10.37626/GA9783959871440.0.26

and having to solve more or less realistic scientific problems, students can improve their scientific literacy in a playful way. Moreover, the use of various digital media and forms of experimentation allows it to consider students' diversity adequately and, subsequently, to deepen their learning (e.g. Seibert et al., 2019). The *ELKE* lab day "A day full of chemistry – Student reporter in lab", for example, makes use of digital forms of documenting experiments. After running through an experimental circuit, the students use digital tools to document the results of their experiments. Using video documentation, the experiments are not reduced to their rational logical findings, but allow a process-oriented deeper reflection of the conducted experiments, as the recording of a video documentation requires more detailed consideration of the subject-specific content. Additionally, using their own smartphones for this type of documentation allows students to return to prior experiments and findings any time and increases motivation by adding a fun aspect. At the same time *ELKE* as a teaching/learning lab offers pre-service (chemistry) teachers the chance to acquire scientific and didactic expertise and reflect upon their professional development (Gross & Pawlak 2020). The topics dealt with in the out-of-school lab *ELKE* cover all types of schools and age groups. So far two experimentation days for primary schools, six experimental days for lower and three for upper secondary have been designed (Groß & Schumacher, 2018).

"CSI VIENNA" – AN EXPERIMENTAL MURDER MYSTERY

The new experimentation day "CSI Vienna" is set within the context of a murder mystery. It gives the students the chance to study and conduct experiments autonomously within the field of nutrition and analyses. During their time at the lab the students take up the roles of investigators who help a police detective to solve the fictional murder of Mr. Argon who has obviously been poisoned. In the course of their investigations the students learn about various components of their daily diet: they learn about the chemical structures of various nutrients as well as their functions for nutrition. Furthermore, the students also get to know how to detect these substances. Conducting their own experiments, the students are able to reduce the number of suspects step by step and to solve the murder case in the end.

In order to gain insights into the effectiveness of this experimentation day for learning, the students and their chemistry teachers are asked to fill in a semi-structured questionnaire assessing the leaning outcomes and the way of learning. First results show that the students could build up chemical content knowledge within the field of nutrition (e.g. "that you can analyse and reconstruct what a person has eaten from the gastric content"). Regarding the practical work in the student lab the participating students claimed that they liked conducting experiments autonomously (e.g. "that we could do experiments ourselves") and that they received support from the supervising pre-service chemistry teachers in case they had comprehension problems (e.g. "that the tutors helped us, whenever we had questions"). Furthermore, the contextualisation of the experimentation day within a murder mystery increased the students' motivation.

The chemistry teachers stated that the participation in the experimentation day lead to the increase of competences in the field of chemistry as well as linguistic competences (e.g. "talking about findings and results") and social competences (e.g. "teamwork, strategic planning").

FURTHER ADAPTIONS OF "CSI VIENNA" – EXPERIENTAL EDUCATION ASPECTS

Due to its overall conception the whole *ELKE* out-of-school lab experience covers a lot of experiential education aspects. The embedding of the lab day into a murder mystery case attributes the whole day features of a modern live action roleplay. *ELKE* focuses on activity-oriented learning and creative problem-solving. In order to emphasise the experiential education experience, it is possible to add another step to the procedure and transfer parts of the murder mystery in an outdoor learning environment; after a brief introduction to the murder case the students are equipped with an investigation box, containing e.g. rubber gloves, plastic bags, tweezers, a fingerprint set and a tablet computer, and are guided towards the crime scene where the corpse of Mr. Argon had been found earlier. The students find the leftovers of an obviously romantic picnic in the park and are asked to collect potential evidence like crumbs, a napkin with a suspicious red stain on it (Is it blood? Is it ketchup? Or is it just lipstick?) or fingerprints. The students are encouraged to use the tablet computer to take pictures of the crime scene and document their proceedings. This step shall help the students to get "into" the murder case, on the one hand, but also to foster their strategic planning competence. At the same time the experience becomes more holistic, as the students not only think about what they possibly have to consider (brains), they also have to collect potential samples (hands) and might even have to overcome disgust when collecting samples of half-eaten food (heart). In the course of the lab day the students will analyse their samples, again, using the tablet computer to document their findings and results. Future *ELKE* days may focus even stronger on doing chemistry outdoors like taking water samples from the Danube and analysing them in a mobile lab, we never know which villain will try to harm the Viennese water system….

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Theoretical Background

The potential of out-of-school labs is out of question. Visiting such an out-of-school lab is an additional opportunity to arouse students' interest in chemistry and encounter typical scientific working methods. Numerous didactic studies have shown that visits in such out-of-school labs foster students' interests in natural sciences [1,2]. It is of major relevance to allow students to experiment autonomously, dealing with relevant, up-to-date topics in authentic scientific learning environments [a.o. 3]. Nonetheless there are hardly any research results that allow generalizable conclusions on the effectiveness of such non-formal learning environments, due to the large variety of different scientific out-of-school learning environments. In a quasi-experimental intervention study Itzek-Greulich et al. (2014) were able to show that linking out-of-school labs and school itself had a positive effect on the development of students' content knowledge [4]. Therefore it can be expected that relating these different learning environments is crucial for optimal learning gains [a.o. 5].

The Concept of *ELKE*

The *ELKE* concept is a new interpretation of an out-of-school lab day for school students at the University of Vienna. The content fits the Austrian curriculum and the materials provided for teachers allow preparation and follow-up activities during the school lessons. Additionally, the competence-oriented design aims at combining the out-of-school learning experience with the traditional chemistry school lessons systematically [6].

The German acronym *ELKE* stands for experimenting (German: 'Experimentieren'), learning (German: 'Lernen') and acquiring competences (German: 'Kompetenzen Erwerben'). In the sense of the Bundesverband der Schülerlabore e.V. "LernortLabor", it can be seen as a *classical student lab* for school students as well as a *teaching/learning Lab* for pre-service chemistry teachers [7]. Each *ELKE* day aims at integrating the underlying principles of experimenting, learning and acquiring competences into the out-of-school lab experience (see figure 1).

The *ELKE* content design

The content range of the classical student lab and teaching/learning lab *ELKE* comprises all types of schools and age groups. So far there are two experimental days for primary level (*ELKE*^{Junior}), six experimental days for lower secondary (*ELKE*) and three experimental days for upper secondary (*ELKE*^{Oberstufe}) (see table 1).

Table 1: Examples of various *ELKE* experimental days (overview: [8])

ELKE	Content
A day full of chemistry – Student reporter in lab [9]	Planning and realizing separation processes based on different properties of substances
Running, sweating ... drinking?! [6]	Detecting ions and assessing so-called sports drinks
Chemistry escape – Find your way (out)! [10]	Telling properties of substances on the basis of structure and verifying these hypotheses; planning and realizing esterification

***ELKE* is adaptable**

Focusing on specific scientific and chemical aspects of didactics, the non-formal learning environments *ELKE* allows to connect relevant topics of chemistry didactics systematically. So each *ELKE* content can get a particular didactic focus: *ELKE S* for example concentrates on language sensitive science and chemistry teaching. *ELKE I* on the other hand, emphasises the development, design and implementation of inclusive learning environments.

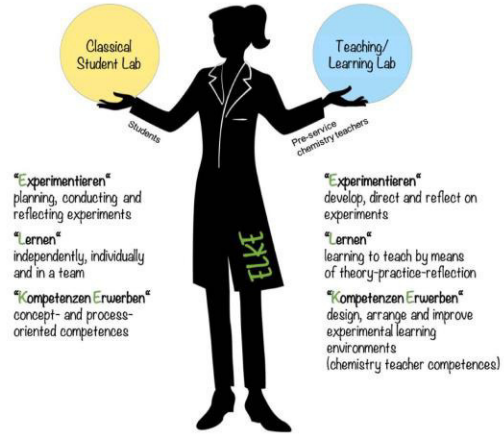


Figure 1: The Concept of *ELKE*. Experimenting (WHAT?) – Learning (HOW?) – Acquiring Competences (WHY?).

"CSI Vienna – Identifying Evidence Chemically"

Student Lab *ELKE* at the University of Vienna

Aims and objectives of the lab day:

For one day the students take the roles of investigators who have to help a police inspector solving the fictional murder mystery of the poisoned Mr. Argon. The students learn about the nutrients of their daily diet (e.g. carbohydrates, proteins, lipids, antioxidants, alcohol or ascorbic acid), as well as the structure and importance of these nutrients. Furthermore, they get familiar with various chemical methods of detecting these nutrients. Additional experiments like the visualisation of fingerprints allow the students to identify themselves with their roles as investigators in the fictional murder mystery [11].

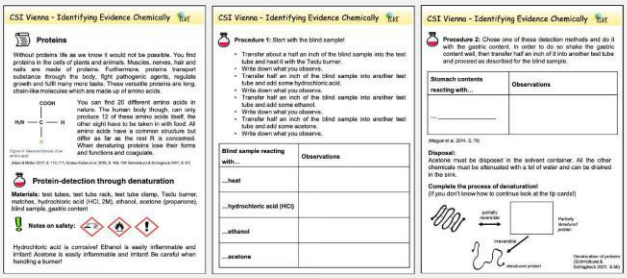
Procedure:

Start (Introduction to the criminal case (podcast)) → Lab phase 1 (Analysis of carbohydrates, starch, proteins and lipids) → Emergency meeting I (Restriction of the suspects) → Lab phase 2 (Analysis of further ingredients (i.a. calcium, sulphate, alcohol, antioxidants)) → Emergency meeting II (Identification of the culprit)

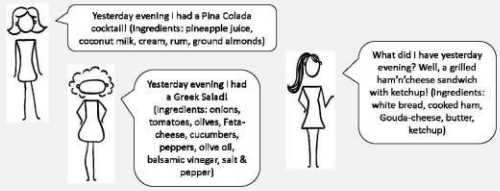
Introduction of the criminal case:

Probably Mr. Argon was poisoned by one of his female neighbours during a romantic picnic for two. After questioning the three main suspects, we know what the three ladies had for dinner on the evening of the murder.
This information is our starting point, my dear investigators! The coroner gave us a sample of Mr. Argon's gastric content. Now we want to analyse the substances from Mr. Argon's stomach and draw conclusions what he might have eaten, because if we know that, we will know who spent the last evening with Mr. Argon and therefore is the culprit!

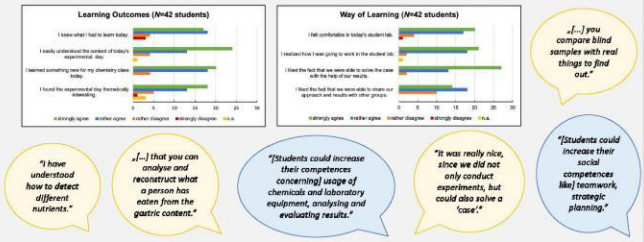
Excerpts from the investigation files for the students:



The Suspects:



Evaluation of the student lab day: semi-structured questionnaires (*N*=42 students, *N*=5 chemistry teachers)



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