Reimagining Student Laboratories: Design and Evaluation of two Innovative Concepts

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Abstract

Most student laboratories organized and cared for by universities try to enrich students' interest in sciences by offering experimental courses for school classes and working closely to their school's curriculum. At the Friedrich Schiller University Jena the working group for chemistry education is aiming to enhance this offer in two ways by intertwining the existing classical student laboratory with digital media elements and providing it with a learning-to-teach-approach.

Learning-to-teach-laboratories are defined as a special organizational form of teacher education. By supervising students during the experimental courses of student laboratories, student teachers can gather teaching experience, thus combining learning activities of students with job-related qualifications of student teachers. Applying this approach to the student laboratory in Jena, chemistry student teachers can experience a change of perspective from the role of a student to a chemistry teacher.

Furthermore, in all stages digital media such as iPads and Whiteboards will be used to improve students' experience of the course. Following the SAMR-model for the integration of learning technology these technical augmentations are aiming to enhance and transform the learning culture of the student laboratory through expansion of the experimental courses by new innovative modules, which will be evaluated by an accompanying study.

Keywords: *teaching chemistry, student laboratories, digitalisation, learning-to-teach-lab*

1. Introduction

Since 2003, the student chemistry laboratory of the Friedrich Schiller University Jena has offered learning opportunities for interested learning groups of all ages. The student laboratory is funded, supported, and supervised by the working group for chemistry education and its staff. The courses, experiments and materials have been developed over the years during various research projects and are constantly updated and expanded. The provided materials include experimental instructions as well as exercises to help understand the science behind them. Due to this set up it can be qualified as a 'classical student laboratory' [1].

When looking for ways to expand this offer, two fruitful approaches were found. To include the student laboratory further in the teachers training a learning-to-teach-course was designed. Moreover, a change to the experimental course design is being made. By including digital media and expanding the experimental courses with e-learning units it is hoped that learning efficiency and motivation will increase.

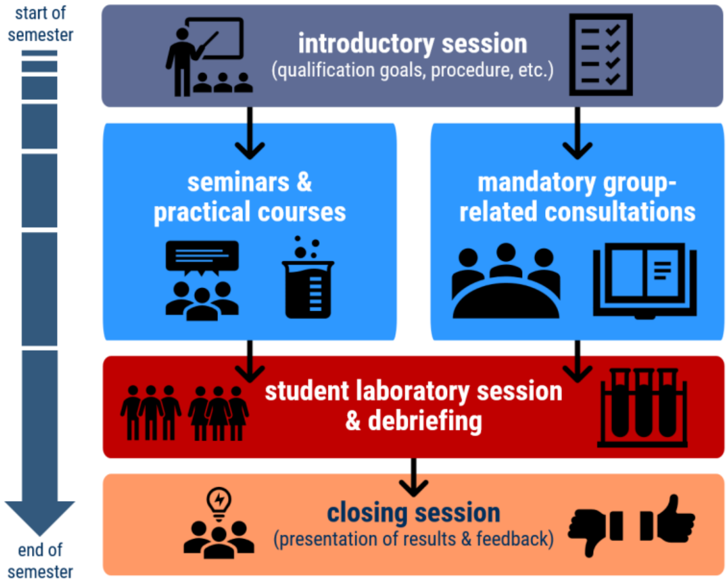
2. Student laboratories and the teacher education

Combining university-based teacher education with practice elements, *learning-to-teach-laboratories* (abbreviated as „LTL“ in the following), especially in the training of prospective STEM teachers, play an increasingly important role [2]. LTL is currently understood to be "[...] *a special organizational form of teacher education in which learning, or support activities of students and the job-related qualification of student teachers are meaningfully linked.*" [3]

2.1. Concept of the LTL in Jena

In a one-semester-module, chemistry student teachers in their first semester can already experience an initial shift of perspective from the role of a student to a chemistry teacher. The focus here is on reflective engagement with beliefs and motivational orientations, which is an important component of teacher professionalism [4].

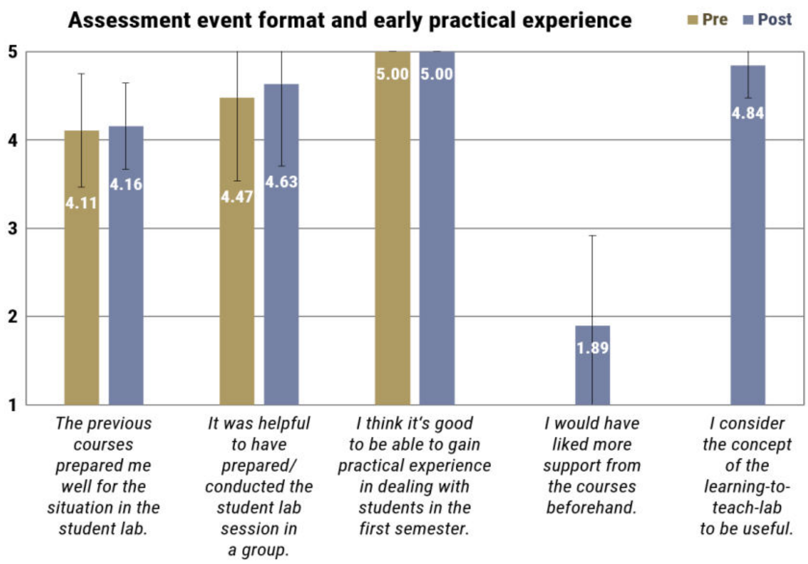
The concept is based on the principle of *subject-specific instructional coaching* which includes three sections: preliminary discussion - teaching sequence - debriefing. The phases of pre- and post-discussion are designed in corresponding to a *co-constructive dialogue* [5] between the student teachers and the lecturer. The participants work in small groups, each planning and carrying out one session in the student laboratory. After an introduction, basic didactic seminars are held for all participants, in which the necessary contents are worked out together. Furthermore, the groups get to know the experiments of their student lab theme in practical courses. Simultaneously, group-related consultations are held to prepare the respective student laboratory session. Each group then carries out the previously planned teaching sequence in the student laboratory. Immediately afterwards, a debriefing session takes place to evaluate the sequence regarding the reflection criteria previously defined. In a final meeting, the group results are compiled, experiences are shared and reflected on together (Fig. 1). During the module, all results and reflections are documented in a portfolio.



(Fig. 1: Schematic semester structure)

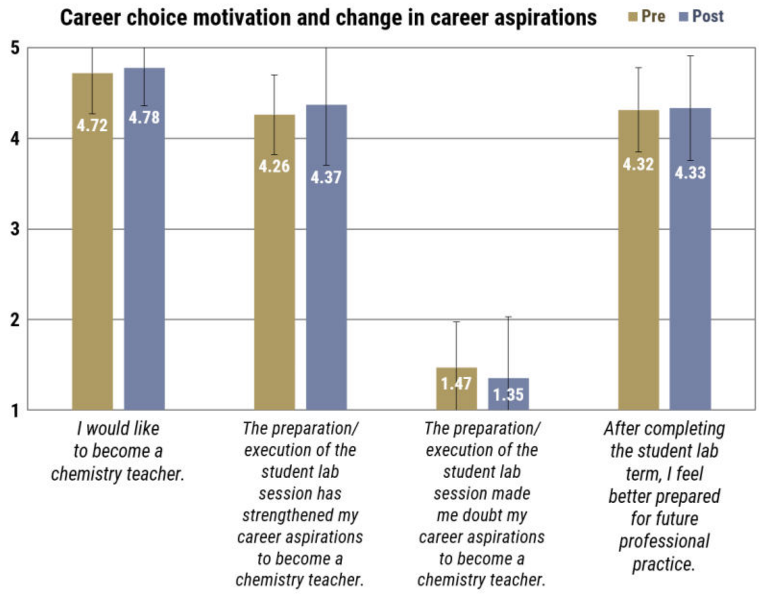
2.2. First evaluation results

Already from first experiences with the concept, the participants rated both the format and the early theory-practice, as profitable overall [6]. In the pilot study, a questionnaire survey in a pre-post design with a five-point Likert scale (1 = *not true* to 5 = *completely true*) was used. A total number of 19 students was surveyed. In the figures, the mean values associated with the items are shown with the respective standard deviation. Regarding the perception of the course format, the data obtained generally indicates that student teachers evaluate the practical experience in the first semester positively. The basic conception is also considered sensible by them. Furthermore, specific course elements, such as working in groups or the prior supervision by the lecturers, are also met with a high level of approval (Fig. 2).



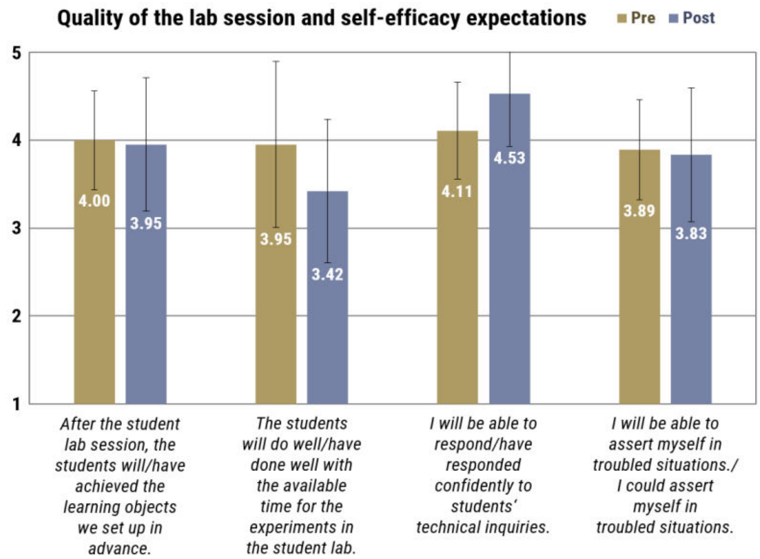
(Fig. 2: Selected items on the assessment of the event format and the participants' perception of the early practical experience)

Concerning the career choice motivation, the piloting results initially indicate that participants chose to study chemistry with a high level of motivation. This remains largely constant after the interaction with the students. It is also evident that the experience tends to reinforce the career aspirations rather than raising doubts about them. From this it can be concluded that an initial experience in the LTL can influence the career choice decision at the start of the study and even reinforce it (Fig. 3).



(Fig. 3: Selected items on the career choice motivation and on possible changes of the wish to become a chemistry teacher)

Finally, the participants assessed the quality of their student lab session and their own competencies (Fig. 4). In the area of these **self-efficacy expectations**, positive effects can be recognized regarding the effectiveness of the unit planned and carried out by the participants as well as their own competencies. These can be observed mainly in the assessment of the students' time management or the evaluation of their own professional responds to students' inquiries. However, in the context of a one-time interaction in LTL and regarding the point of time in the study, the effects are to be assessed as low. The high standard deviations for many items indicate that the evaluation by the participants seems to differ significantly on an individual level.



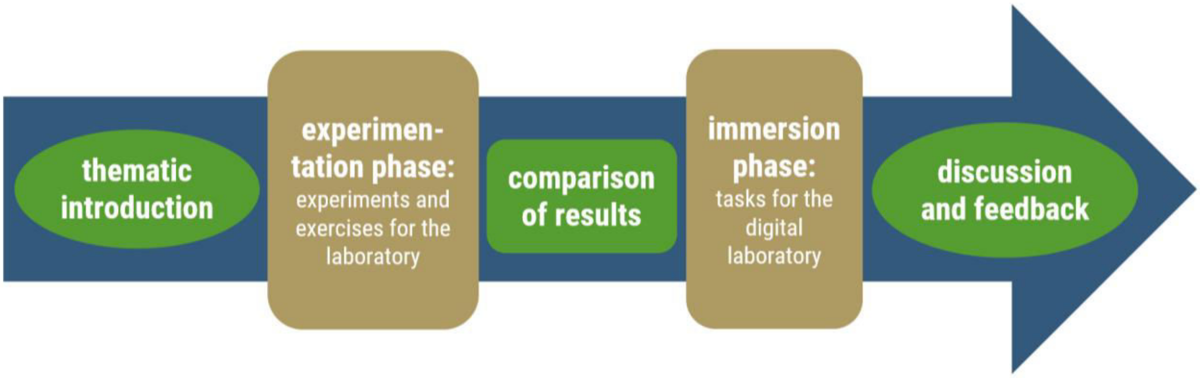
(Fig. 4: Selected items on self-assessed quality of the student lab session and on aspects of self-efficacy expectations)

3. Digitalisation and expansion of the student laboratory in Jena

The existing student laboratory is to be expanded at several central points with innovative modules. One aim is to link classical and well-established aspects with future-oriented possibilities of the digital world. Digital media should be used with a sense of proportion and by utilising their specific potential. Therefore, digital aspects will be integrated in the different stages of the student laboratory day to different extents.

3.1. Renewed concept of the student laboratory

The renewed concept and schedule of a student laboratory day is illustrated in the following figure:

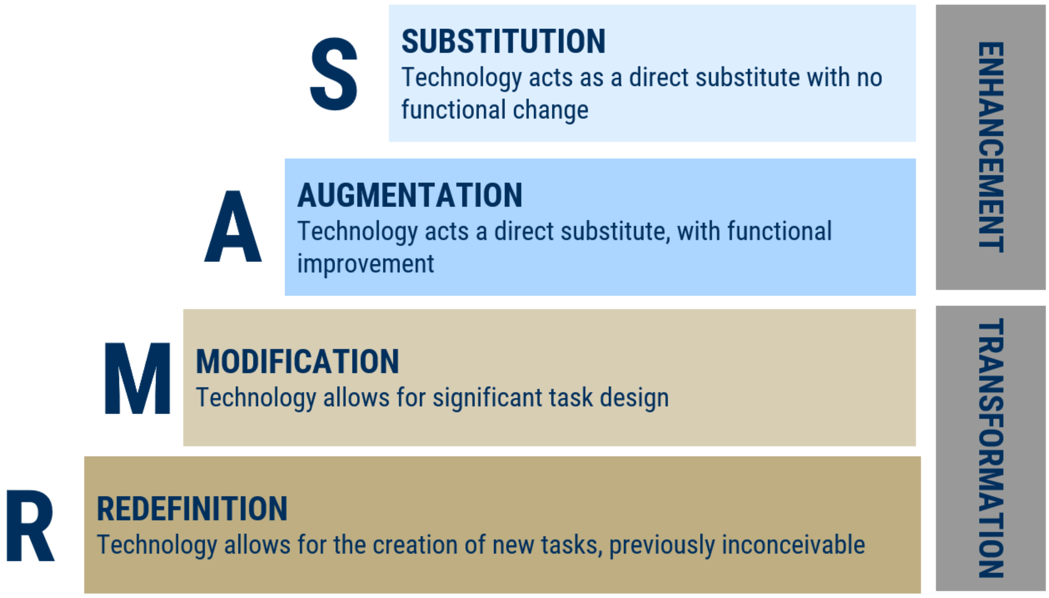


(Fig. 5: Renewed sequence of the student laboratory)

As preparation for the experimentation phase, a thematic introduction is planned, in which the stations and their focal points are presented to get a distinct insight into the topic and to prepare the students for the experiments accordingly. The experimentation phase itself is essentially identical to the previous contents of the classical student laboratory. Existing experiments from the student lab, which have proven themselves during regular realizations, can therefore be adopted for this phase.
Afterwards, a comparison of the results from the student laboratory should take place. The students can compare their results for each station and can correct previous mistakes and unclarities. With the planned immersion phase, a completely new format will now find its way into the student lab day. The students will have the opportunity to apply their knowledge and deepen their understanding of the subject-related aspects of the stations. A short discussion and feedback session should conclude the day and offer the students time and space for reflection. In addition, any topics that emerge here can offer suggestions for the follow-up of the student lab day in school.

3.2. Establishing the concept of a digital student laboratory

Digital media will be integrated into the work processes in a variety of ways. First, the previous experimental instructions for the experimentation phase are gradually being converted into digital experimental scripts. In the sense of e-books these digital experimental scripts can already contain graphics or other interactive elements that extend the functionality of analogue scripts. In the sense of the SAMR model [7] analogue content will be directly replaced by digital content and its range of functions expanded. Thus, the first stage in the integration of learning technology, enhancement, is achieved.
The use of iPads also makes it possible to design tasks in a new and open way: The app *Prezi* will be used for the thematic introduction. In this app, presentations no longer correspond to a linear format but can be perceived interactively. In this way, several layers of the presentation can be incorporated, and the reader can grasp the information in a self-determined way. The software *Explain Everything* will be used in the immersion phase. This app can be used to simulate a whiteboard on any device, which can be prepared in different ways depending on the task. Thus, additional help, videos, links, etc. can be integrated, thereby transforming the learning environment. The next stage of integrating learning technology in the SAMR model, transformation, is thus achieved and the potential of digital media largely realised.



(Fig. 6: Reconstruction of the SAMR model)

3.3. Evaluation and integration of the concept

The newly created concept is to be reviewed subsequently. For this purpose, a study with about 100 students is planned. The learning effectiveness will be examined by a pre-test/ post-test design. In the beginning, only the immersion phase will be evaluated in comparison to groups who will instead experience the classical student laboratory schedule with more experiments. It will be investigated whether the pupils who have gone through the student laboratory with the digital immersion phase achieve better results and thus learning progress than those who have only gone through the experimentation phase. This would be a first indication that the new offer is more effective for learning than the previous offer. The results of the study will then be analysed, and conclusions drawn about further development possibilities and the future orientation of the student lab. A follow-up questionnaire is planned, examining long-term effects of the intervention.

4. References

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