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Digital and difficulty-differentiated Learning Modules in a Student Laboratory Context: A Pilot Study

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At the Friedrich-Schiller-University Jena a student laboratory dedicated to the research and usage of digital media in the field of chemistry education is being created. The underlying concept of the digitalchemlab has been tested and evaluated for the first time last summer alongside a new digital and complexity-differentiated learning module. After internal piloting and with testing it with university students, the learning module according to the new concept digitalchemlab was conducted with three school classes with pupils of age 13-15 (N = 65). The pilot study mainly focussed on the medium and the method. Quantitative methods (pre- and post-tests, plus a questionnaire after completing each task) as well as qualitative methods (student interviews) were used to determine the best possible use of the digital learning module. First results of the study will be presented in this paper.

Keywords: *digital media, student laboratory, learning outcome, motivation*

1. Introduction

Digital media can be used in a variety of ways to enhance students' motivation and improve their learning experience and even outcome [1]. At the Friedrich-Schiller-University Jena a special focus lies on the potential inherent in digital media of creating a personalised learning environment. With this in mind, a new concept for conducting student laboratory courses has been created, called *digitalchemlab*. In order to evaluate and test this concept a pilot study was conducted last summer. The concept itself, the outlay and conduction of the study plus first results and an outlook for next summer's main study will be presented in the following.

2. The *digitalchemlab* and conduction of the study

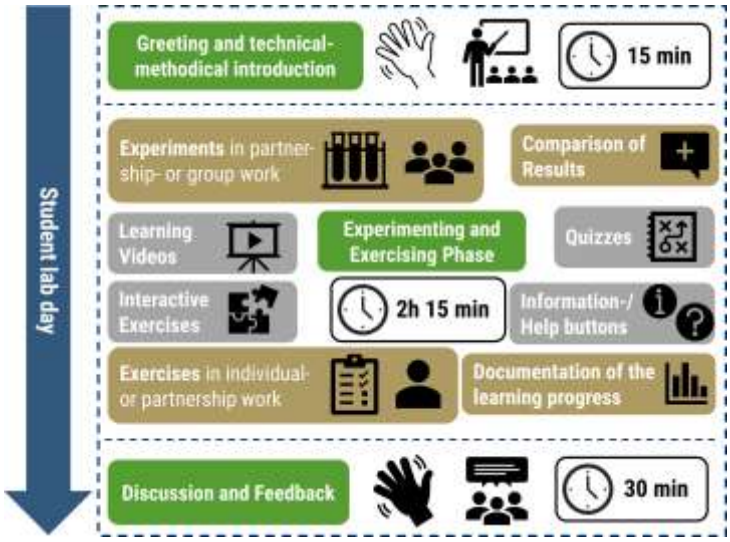

Fig. 1: The concept *digitalchemlab*

Digitalchemlab is a concept for digital and difficulty-differentiated learning in a student laboratory context [2]. The goal of the concept is to implement digital elements into everyday student laboratory courses while at the same time use these elements to enhance students' motivation of engaging with the topic but also offer ways to individualize the learning experience. As Figure 1 shows after a short introduction into the technical and methodical aspects of the day, the students then have two hours in

the student laboratory to experiment and exercise. This experimenting and exercising phase includes two types of tasks:

1. Classical experiments to encounter scientific phenomenon in a hands- and minds-on approach [3].
2. Exercises highlighting the underlying theory or covering everyday aspects of the topic.

Both types of tasks are being supported by digital media such as learning videos, interactive tasks (learningapps.org), quizzes or interactive information and help buttons (thinglink.com). The students can then compare their results with a solution for each task and document their learning progress. These tasks are embedded in a so-called digital differentiation matrix, meaning that they are organised with increasing subject complexity as well as cognitive complexity. On their iPad the students can thus choose which tasks to start with an create an individualized experience of the day.

A learning module with the topic “household detergents” has been created according to the previously described concept. This learning module was subject of intensive research from April to July 2022. Before piloting it with students, the learning module has been internally tested and evaluated and with student teachers in their last year of study. After a short revision phase, three school classes tested this module. The pilot study followed a pre-test, intervention, post-test, follow-up-design. Furthermore, student interviews and questionnaires after each task were used to gain perspective on the way the students experienced the learning module. Three research questions stood out:

1. Does the learning module affect students’ knowledge, interest, and emotions during the day?
2. How do the students value the learning module and specifically the usage of digital media?
3. How do the students use the learning module (i.e., choice of tasks, usage of digital media)?

Focussing on these questions the pilot study was conducted within two months from June to July last year. The pre- and post-test were conducted by 65 students, while the follow-up-test had 54 students.

3. First results of the study

3.1. Affects on knowledge, interest and emotions

Different effects on knowledge, interest and emotions can be seen, when reviewing the data. The knowledge of acid-base-chemistry was measured with a self-created twelve-item scale. An increase in this knowledge can be seen between pre- and post-test, while the knowledge slowly decreases in comparison to the follow-up-test but remains higher than before the intervention (see Fig. 2). Similar results can be yielded from investigating the growth of knowledge cocnerning household detergents. An open knowledge measurement with five items was used for this. The students could distinguish much better afterwards between different types of household detergents and how different soiling can be removed. Thus, the learning module achieved at least temporary effects on the knowledge of the students.

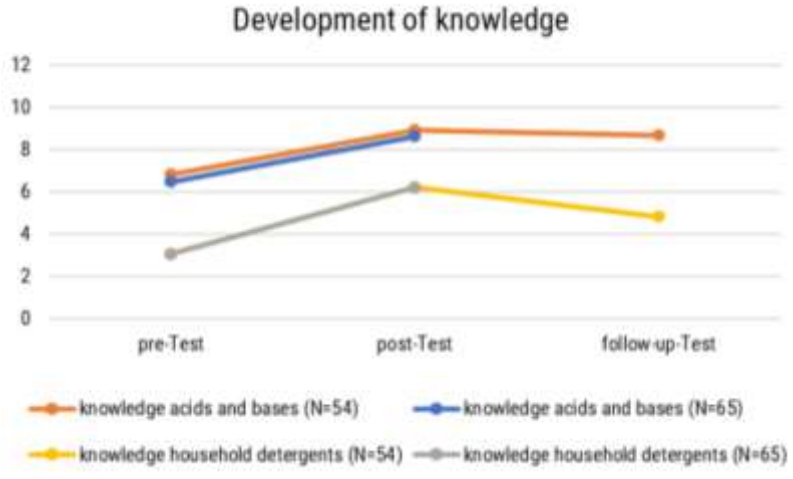

Fig. 2: Development of knowledge in the pilot study

The interest concerning the subject chemistry and the topic of household detergents was measured using revised items from the PISA-study [4] and from a questionnaire for current motivation [5]. Unfortunately, the interest in these areas showed only little change from pre- to follow-up-test or pre- to post-test respectively (see Fig. 3). The persistent stability of subject interest could be predicted from similar studies (see [6] for a recent overview); this was also backed up by results of an additional questionnaire in the follow-up test ("Did the visit of the student lab change your attitude towards the subject of chemistry?" 92% answered "No" and when questioned "Why?" showed an either persistent positive or negative attitude). The results concerning the topic interest seem surprising at first though. Even though a slight increase after the post-test can be seen, either the topic itself seems to be less appealing to younger students retrospectively in the follow-up-test or their interest in the topic seems to be sufficiently satisfied by the intervention not sparking further interaction with the topic.

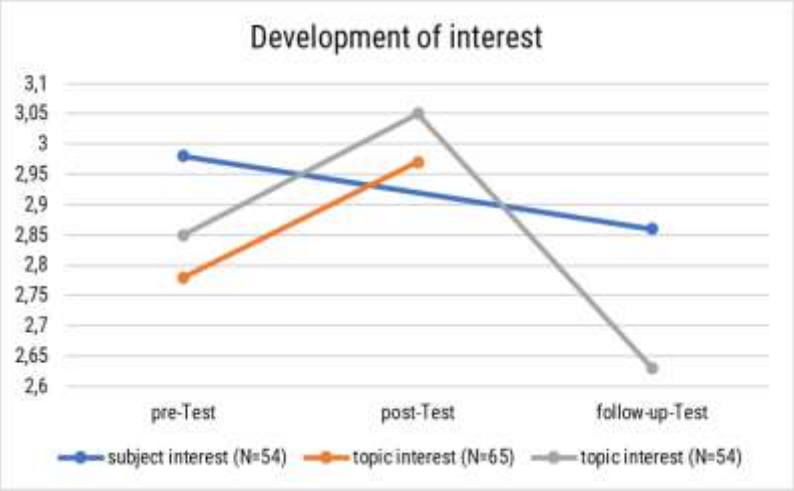

Fig. 3: Development of interest in the pilot study

When asked about how they felt towards the upcoming or, respectively, the past student lab day, it could be shown that the intervention yielded positive results (see Fig. 4). The emotion of fun could be significantly increased, the anticipated emotions of frustration, confusion and boredom could be significantly decreased when comparing pre- and post-test. The curiosity decreased significantly though, possibly showing the high level of informativeness of the learning module.

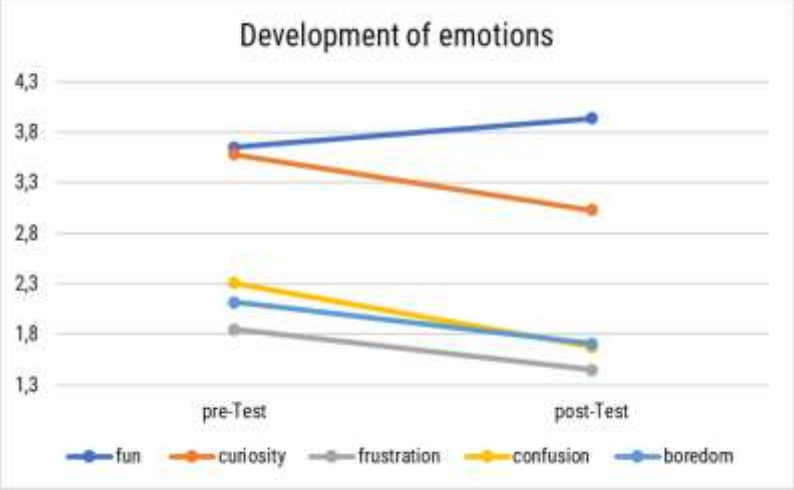

Fig. 4: Development of emotions in the pilot study

3.2. Valuation of the learning module

When asked to rate different aspects of the learning module and the learning module itself the students gave high ratings on a five-stage Likert-scale (see Fig. 5). The learning module (4.19), the differentiation matrix (4.18) and the implementation of iPads (4.49) were all appreciated greatly by the

students. Difficulty (3.18) and duration (3.29) were ranked very closely to the anticipated mark (3 = “exactly right”). When asked “What did you like most about the learning module?” an overwhelming 88% of participants answered, while “working with digital media” (39%) and “conducting experiments” (26%) showed the most answers. When asked “What can be improved about the learning module?” only 33% answered, with “technical aspects” (19%) and “content aspects” (12%) ranking as top categories. Overall, this is a very positive result underlying specifically the big role of digital media and experiments for the successful execution of the learning module.

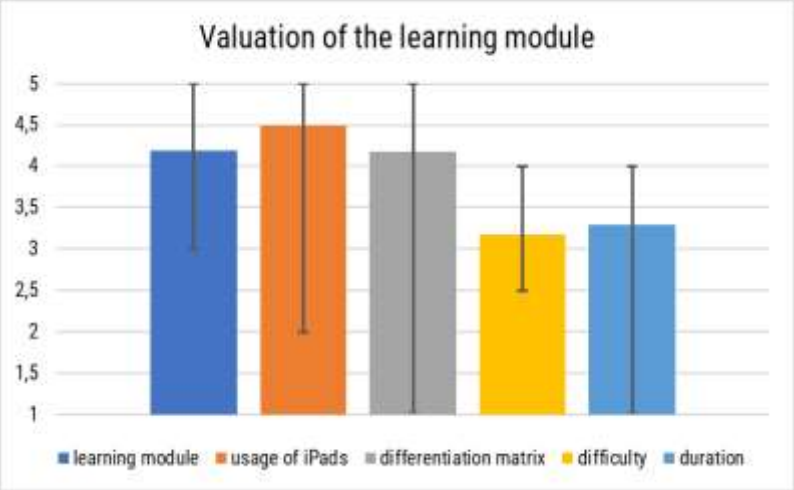

Fig. 5: Valuation of the learning module (with minimum and maximum answers)

3.3. Usage of the learning module

When looking at the chosen tasks and the usage of the learning module multiple interesting aspects catch the eye. The number of chosen tasks decreases with increasing topic and cognitive complexity (see Fig. 6) showing that the students are inclined to choose easier tasks more often when given the option. The material essential for solving the tasks i.e., texts, instructions and exercise sheets was used most frequently as well as digital media like learning videos or interactive tasks. Information and help buttons were used much less and only while solving more difficult tasks. The solutions were used less than expected and the quizzes were used very rarely. Since self-regulation options and checking their results with a prepared solution might not be methods used every day in school classes the students might not have the same tendencies to use these rather unusual methods. The quizzes might need to be placed more prominently to unfold their potential for checking the progress in the different topic areas. When comparing the difficulty and effort level of the different tasks it can be shown that the students perceive the most complex tasks also as most complex and need the most effort for it. This is a good indicator that the perceived and intended levels of complexity match and thus a good sign for the structure of the learning module.

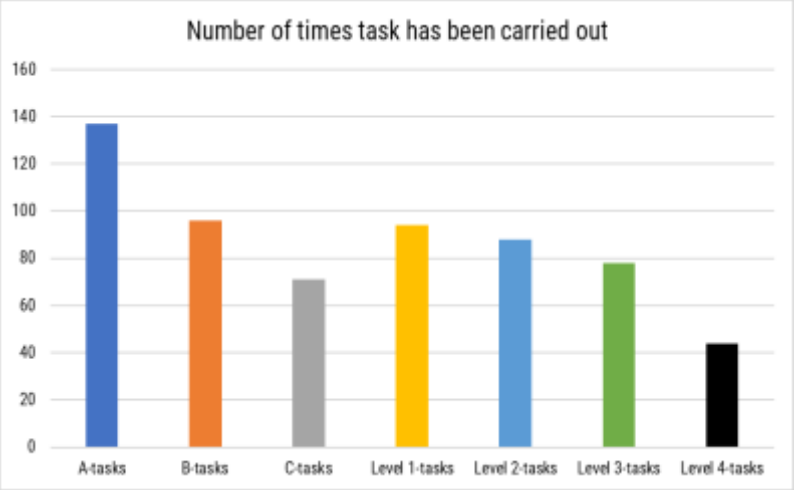

Fig. 6: Number of times tasks of different complexity have been carried out.

Further questions remain yet unanswered: When comparing the students' choice of tasks are there any specific learning pathways? Are they choosing tasks similar or appropriate for their level of knowledge? Are there differences in sub-groups for example between students with higher or lower grades in chemistry/ in general? Some of these questions will be addressed in the main study, which will be conducted in summer 2023.

5. Conclusion and outlook

The results of the pilot study show the effectiveness and advantages of the digital learning module and therefore of the newly created concept. Knowledge and the emotional experience can be influenced by the intervention meaning that the students are having fun during the day and are learning a lot in the process. The learning module, the usage of iPads and the differentiation matrix are all valued very highly indicating the positive influence of these methods. Using digital media while also conducting experiments seems to be a great way to motivate the students. The complexity of each task seems to be appropriate and a fitting positioning of the tasks in the differentiation matrix can be derived from the results.

A main study will be held in May and June 2023 aiming to answer the outlined further going questions and to support the results of the pilot study. 13 classes, equalling 300 students are expected to visit the student laboratory and test the learning module. The research questions remain largely the same, with a bigger focus on the students' choice of tasks. Two thirds of the groups will conduct the learning module as described above. The other third will not work with a differentiation matrix but rather conduct the learning module as a simple station learning. Results from both groups will be compared to determine if the method of the differentiation matrix really makes a difference if it comes to the choices of the students and the results of the learning module. Looking into the future theses aspects will decide if learning modules like these can be implemented further into the student lab day while also unfolding the great potential of digitalisation and differentiation in student laboratories and by extension in chemistry education in general.

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