Pre-service Teachers' Preparedness to Use Digital Tools in their Teaching using the Example of Laboratory Simulations

Clemens Hoffmann[1], Elizabeth Marie Watts[2]

Friedrich-Schiller-University Jena, Germany[1]
Kassel University, Germany[2]

Abstract

Digital competencies are understood as knowledge, skills, and attitudes necessary for professional use of digital tools to support teaching and learning. As part of a pilot project at the Friedrich-Schiller-University Jena, a course was designed in which pre-service science teachers became familiar with different digital tools, reflected on their use in the classroom, and were encouraged to design ideas for digital support of teaching and learning processes in the course. To this end, students worked with a laboratory simulation software (Labster) and developed initial projects for its use in differentiated instruction. Laboratory simulation software provides a new approach to experimentation in science without the need for physical laboratory equipment. The digital format thus makes experiments possible that may not be able to be conducted due to the lack of necessary equipment. In addition, a digital format allows experimentation experiences to be more easily adapted to the diverse needs of learners. This is in part due to the accessibility that comes from being independent of physical lab spaces, and partly due to the ability to quickly and immediately access additional information, help, and feedback. The digital competencies of the pre-service teachers were surveyed by means of a questionnaire. More specifically, it was assessed how confident they felt in using digital tools in the classroom in general and in experimentation in particular.

Keywords: *digital competencies, digital tools, pre-service teachers, laboratory simulations*

1. Introduction

The "Progressive Science Education" project was funded IMPULSE[project] at the Friedrich-Schiller-University Jena. The goal of the project was to address accessibility and equity in science education using digital tools. One aspect of the project was Virtual School Lab in which pre-service teachers learned to use simulated laboratory software from *Labster*. Here digital competencies were addressed in the sense of a broad concept of competency, which are acquired by pre-service teachers and further professionalized in order to be able to be later reflected in their own school and lesson design and continuously developed further [1]. Specifically, the possible uses of simulated laboratory environments and the benefits that arise from this use for teaching practice were explored and examined.

2. Simulated laboratory environments

Labster software was chosen for the Virtual School Lab project because it offers the most simulations and excellent graphics. The high quality of the simulations is due in part to collaboration with several scientific institutions that review and influence the quality, accurate content, and presentation of the labs. In addition, a lot is being invested in didactic developments for the simulations and there are already some studies on the effectiveness of the *Labster* simulations [2, 3, 4, 5, 6]. The use of *Labster* therefore offers numerous advantages. It offers real problems in authentic contexts, safe experimentation, individual learning pace, research-based and in-depth learning approaches supported by quizzes and further information, playful elements as well as storytelling and gamification approaches for increased engagement.

While *Labster* was originally only available in English, many simulations and corresponding lab protocols were translated into German in 2020 and 2021. This made the use of *Labster* much more appropriate for school use than just a couple years prior.

3. Course concept

In order to explore and investigate the possible uses of simulated laboratory environments, a seminar for pre-service biology teachers was developed that allowed students to become familiar with *Labster* and practice using it. Due to the global pandemic, the course was carried out completely online in the summer semester of 2021 at the Friedrich-Schiller-University Jena. The course was divided into four sections, which the students could complete in eight to ten hours. The initial meeting served as orientation, in which the students could familiarize themselves with the software. This was followed by independent testing phase whereby the pre-service teachers could explore a variety of simulations (at least three). Building on their experiences, the students developed initial classroom implementation ideas on how they would use *Labster* in the classroom. Here one of the goals was not only to examine how *Labster* could be used to meeting curriculum goals but also to support equity and inclusion in the classroom. In a final phase, the students presented their project ideas and received feedback on the feasibility as well as on the opportunities and challenges of using laboratory simulations in the classroom.

4. Digital competencies

Digital competences are defined as the knowledge, skills and attitudes that are necessary for a professional use of digital media and tools to support teaching and learning [7, 8, 9]. It is therefore about the expertise of instructors in dealing with digital media and tools, who display pedagogical and didactic judgment and an awareness of their effects on the learning and digital education of students [10]. Three models are well established as a means to measure differentiated sub-areas of teachers' digital skills, namely the *TPACK framework model* by Köhler and Mishra [11], the *K19+ framework model* by Schultz-Pernice et al., [12] and the *DiKoLAN* orientation framework by Becker et al. [7]. Yet, none of these three models focus specifically on the attitudes and preparedness to use digital tools. These aspects represent an important condition for the acceptance and use of digital tools, which is why an additional model was necessary. For that purpose, we used the "Teachers' preparedness to use ICT in education" tool developed by Viberg et al. [13], which was developed based on *TPACK* and on the work from Venkatesh et al. on the *Unified Theory of Acceptance and Use of Technology* [14].

5. Data collection

Pre-post-questionnaires were used to collect date prior to the beginning of the course and following the conclusion of the course. A total of 70 students participated in the course and the questionnaire. The preparedness of the pre-service teachers to use digital tools was surveyed using an online tool *SoSciSurvey*. As part of the quantitative accompanying research, the preparedness of the students to use digital tools in the classroom was examined. Hereby, digital tools were defined as all digital technologies that can be used to support student learning (e.g., game-based learning, simulated laboratories, VR, AR, LMS, applications for collaborative work). Based on Viberg et al. [13], the preparedness to use digital tools is to be regarded as a constitutive part of teachers' digital competence, which affects attitudes and dispositions. Preparedness in this sense comprises seven sub-areas: (1) the ability to use digital tools, (2) social influences and support, (3) the intention to use, (4) the usefulness and efficiency, (5) the pedagogical potential, (6) the awareness of support and (7) the awareness of limitations. For the study, the questionnaire [13] was translated into German and adapted to allow pre-service teachers to better respond to the items. Two subscales were excluded (2 and 6) due to their explicit reference to in-service practices. In the following, the two subscales for the ability to use digital tools and the pedagogical potential of the same are discussed. The items serve as examples:

- I find it easy to learn how to use digital tools. (ability to use digital tools)
- I am aware of the possibilities and limitations of digital tools in my teaching. (pedagogical potential)

6. Results

Ultimately, only 31 completed pre-post-questionnaires could be used for further analyses. The Wilcoxon test was used to analyze the pre-post-results. Two statistically significant results could be identified. On the one hand, the self-assessed abilities of the respondents to use digital tools before participating in the *Labster* training differ significantly from their assessment afterwards with a strong positive effect (N = 31, z = -3.608, p = .000, r = .65). On the other hand, the estimated pedagogical potential that the respondents attribute to the use of digital tools before participation differs significantly from their assessment afterwards with a strong positive effect (N = 31, z = -3.067, p = .002, r = .55). Figure 1 shows the boxplots for the differences described.

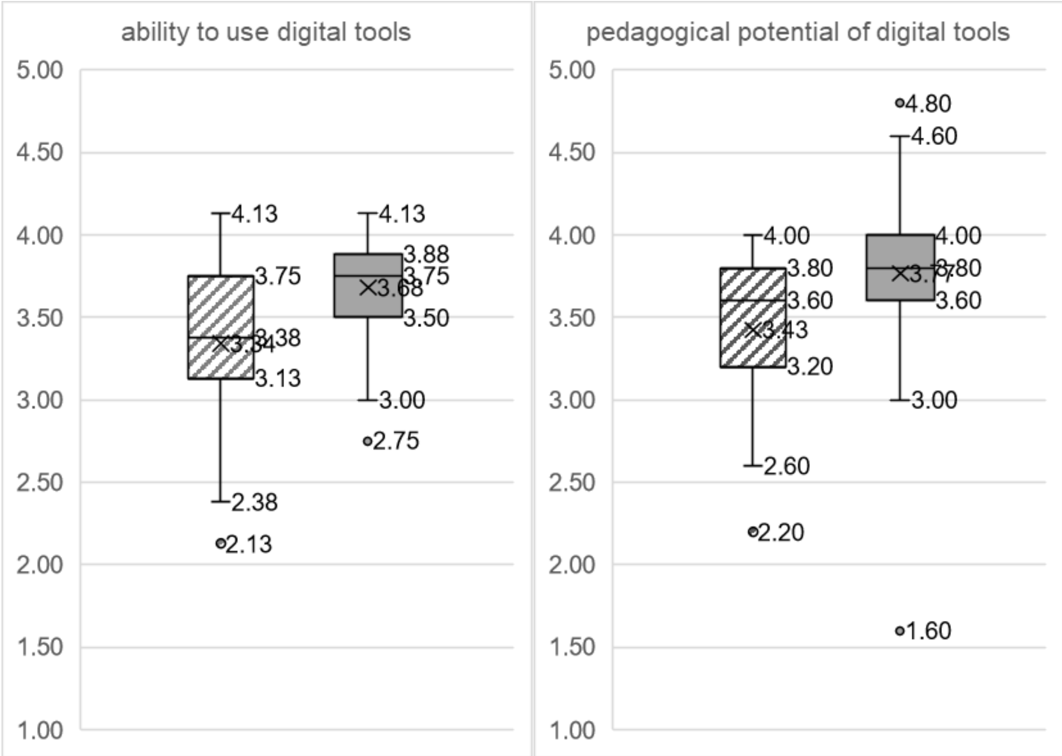

Fig. 1: Boxplots in comparison before (striped) and after the intervention (grey) for the self-assessed ability to use (left) and the assessed pedagogical potential of digital tools (right)

The two significant results show that even short-term interventions can have strong effects on the preparedness to use digital tools - at least if the students themselves become active. In total, the participants worked between eight and ten hours with *Labster*, but only 20 minutes of that time they received concrete input for use by the lecturers. This change among the students was supported by the task of designing a classroom implementation project that was as concrete as possible and in which the digital tool used was used. There are no significant differences for the scales of intention to use, awareness of limitations, and estimated usefulness and efficiency. However, at least one positive trend can be seen for the latter.

7. Conclusion

While the sample size was too small to make any general conclusions, the results give an indication of how pre-service courses can support the development of digital skills and preparedness. While the course was relatively short and much of the work was done asynchronously, we believe that the positive influence on both self-assessed ability and pedagogical potential is largely due to the project-based format of the course (i.e. active engagement with the introduced digital tool (*Labster*), development of concrete implementation ideas for the classroom, and peer-feedback about these implementation ideas).

References

[1] van Ackeren, I., Aufenanger, S., Eickelmann, B., Friedrich, S., Kammerl, R., Knopf, J. et al. “Digitalisierung in der Lehrerbildung. Herausforderungen, Entwicklungsfelder und Förderung von Gesamtkonzepten”, Die Deutsche Schule (DDS), 111(1), 103–119, 2019.

[2] Bonde, M. T., Makransky, G., Wandall, J., Larsen, M. V., Morsing, M., Jarmer, H., & Sommer, M. O. “Improving biotech education through gamified laboratory simulations”, Nature Biotechnology, 32(7), 694-697, 2014.

[3] Fleuren, D. “Open MINT Labs: Mit virtuellen Laboren zu höherem Lernerfolg”, S. Aßmann, P. Bettinger, D. Bücker, S. Hofues, U. Lucke, M. Schiefner-Rohs, C. Schramm, M. Schumann, & T. van Treeck (Ed.) “Lern- und Bildungsprozesse gestalten. Junges Forum Medien und Hochschulentwicklung (JFMH13)”, 141-150, Münster; New York, Waxmann, 2016.

[4] Schäfers, M. S., Schmiedebach, M., & Wegner, C. “Virtuelle Labore im Biologieunterricht: Auswirkungen von Labster auf die Selbsteinschätzung von Schülerinnen und Schülern”, MedienPädagogik: Zeitschrift für Theorie und Praxis der Medienbildung, 140-167, 2020.

[5] Stauffer, S. “Laborsimulationen Labster. Mit virtuellen Experimenten zum Lernerfolg”, BIOspektrum, 25(1), 104, 2019.
[6] Wright, D. “Conducting Science Labs in a Virtual World” Science Scope, 44(2), 10-15, 2020.
[7] Becker, S., Bruckermann, T., Finger, A., Huwer, J., Kremser, E., Meier, M. et al. “Orientierungsrahmen Digitale Kompetenzen für das Lehramt in den Naturwissenschaften – DiKoLAN”, S. Becker, J. Meßinger-Koppelt & C. Thyssen (Ed.) “Digitale Basiskompetenzen. Orientierungshilfe und Praxisbeispiele für die universitäre Lehramtsausbildung in den Naturwissenschaften”, 14–43, Hamburg: Joachim Herz Stiftung, 2020.
[8] Instefjord, E. “Appropriation of Digital Competence in Teacher Education”, Nordic Journal of Digital Literacy, 9(4), 313–329, 2014.
[9] Røkenes, F. M. & Krumsvik, R. J. “Prepared to teach ESL with ICT? A study of digital competence in Norwegian teacher education” Computers & Education, 97, 1–20, 2016.
[10] Krumsvik, R. J. “Digital competence in Norwegian teacher education and schools”, Högre utbildning, 1(1), 39–51, 2011.
[11] Köhler, M. J. & Mishra, P. “What is technological pedagogical content knowledge?”, Contemporary Issues in Technology and Teacher Education, 9(1), 60–70, 2009.
[12] Schultz-Pernice, F., Kotzebue, L. von, Franke, U., Ascherl, C., Hirner, C., Neuhaus, B. et al. “Kernkompetenzen von Lehrkräften für das Unterrichten in einer digitalisierten Welt”, merz – medien + erziehung, Zeitschrift für Medienpädagogik, (4), 65-74, 2017.
[13] Viberg, O., Mavroudi, A., Khalil, M. & Bälter, O. “Validating an Instrument to Measure Teachers’ Preparedness to Use Digital Technology in their Teaching”, Nordic Journal of Digital Literacy, 15(01), 38–54, 2020.
[14] Venkatesh, V., Morris, M. G., Davis, G. B. & Davis, F. D. “User Acceptance of Information Technology: Toward a Unified View”, MIS Quarterly, 27(3), 425–478, 2003.