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EDITED AND REVIEWED BY
Clifford A. Shaffer,
Virginia Tech, United States

*CORRESPONDENCE
Johannes Huwer
✉ johannes.huwer@uni-konstanz.de

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Editorial: STEM/science teacher education for the future: "from TPaCK to DPaCK"

Johannes Huwer[1,2]*, Till Bruckermann[3], Christoph Thyssen[4] and Sebastian Becker-Genschow[5]

[1]Science Education, Department of Chemistry, University of Konstanz, Konstanz, Germany, [2]Science Education, Thurgau University of Education, Kreuzlingen, Switzerland, [3]Institute of Education, Leibniz University Hannover, Hanover, Germany, [4]Biology Education, Department of Biology, RPTU Kaiserslautern-Landau, Kaiserslautern, Germany, [5]Faculty of Mathematics and Natural Sciences, Digital Education Research, University of Cologne, Cologne, Germany

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Editorial on the Research Topic
STEM/science teacher education for the future: "from TPaCK to DPaCK"

At a time when digital literacy is of paramount importance, there is a great need to promote subject-specific and sociocultural digital competencies among the facilitators of digital literacy, i.e., pre-service and in-service teachers. This need is driven by the goal of fostering a digitally literate society and entails the task of explicitly identifying, naming, and addressing of such skills in the education system. The structure of such competencies is described by frameworks such as TPACK (Koehler et al., 2013). However, even the creators of this model say that the model needs to be adapted due to the intensity of the digital transformation in society and culture (Mishra et al., 2023). DPACK (Huwer et al., 2019; Thyssen et al., 2023) and DiKoLAN (Becker et al., 2020; Kotzebue et al., 2021) explicitly cover digitality to consider these aspects. In the case of DiKoLAN, a progression of competencies is even described. The aim of this Research Topic is to attempt to define these competencies and to discuss the practical implementation of competence development against the backdrop of the DPACK model and the DiKoLAN framework, in order to do justice to the growing importance of socio-cultural aspects and subject-specific competences.

The DPACK model: expanding TPACK with sociocultural knowledge

The TPACK framework (Technological Pedagogical Content Knowledge, Koehler et al., 2013) describes the knowledge facets (technological, pedagogical, content and their intersections) that teachers need to promote digital literacy. The DPACK model extends the TPACK framework by incorporating digitality, acknowledging the importance of digital cultural transformations in education. It emphasizes the need for teachers to possess knowledge and skills that go beyond technological, pedagogical, and content

knowledge to encompass sociocultural awareness in a digital world. This model represents a paradigm shift that recognizes the impact of digital transformation on communication, mediatization, and society.

The DiKoLAN framework: operationalizing TPACK with digital competencies for science education

DiKoLAN focuses specifically on natural sciences, structuring competencies in areas such as data acquisition, data processing, simulation and modeling, presentation, documentation, information search, and evaluation, communication and collaboration. In the natural sciences, these competence areas can help to specify the professional knowledge needed to promote digital literacy in the classroom, because many descriptions of TPACK (and DPACK) are still generic (e.g., Schmidt et al., 2009). In doing so, the DiKoLAN framework provides a more nuanced and specialized framework for developing competencies in science education that align with the broader tenets of DPACK.

Contributing manuscripts of the Research Topic

Based on a systematic literature review, Aumann et al. develop a rubric for assessing enacted TPACK with a focus on digital media use and instructional approaches, i.e., student-generated explainer videos. Thereby, their rubric addresses the knowledge base of two more general competencies of teachers: presentation and communication/collaboration. Although explainer videos include a societal dimension, in that they are new forms of communication and self-expression, the sociocultural knowledge sphere was excluded in order to reduce the complexity of the rubric. They report the absence of the socio-cultural domain as a limitation and a challenge for future research.

Based on the explanations of Max et al. on their concept of promoting TPACK specifically in an educational makerspace, it becomes clear, particularly with regard to the development of competences that the authors locate in the area of PK, such as communication, collaboration and experience sharing, that sociocultural competences in the area of digital technologies are considered essential, even if they are not explicitly considered in the TPACK model. With the increasing importance of feedback and adaptive teaching (e.g., Liu et al., 2022), related technological systems and user preferences, such competences, should be more clearly named and focused and may be explicitly considered, as it is the case in DPACK.

In the study by Freese et al., physics teachers were trained in the use of Augmented Reality (AR) in order to improve their digital and modeling skills for the targeted use of AR experiments in their lessons. The implementation and creation of 3D models in the context of AR can be categorized in DiKoLAN and thus offers a structured orientation about AR-related competencies for prospective science teachers. For many teachers, digitality has not yet become a reality, as the digital equipment is not yet sufficiently available. According to DPACK, the skills required to match future students' prevailing level of experience are still a matter for the future.

As the aim of Ripsam and Nerdel's study, to evaluate teachers' digital competencies in the context of using three different Augmented Reality (AR) scenarios, suggests, the future acceptance of new media types may affect teaching and learning. The study focused on the TPACK area of the DPACK model, but also considered the sociological-cultural effects such as self-efficacy and the users' attitudes toward the use of AR. The teacher competencies addressed can be found in DiKoLAN, which is the "standards for teacher training"—according to the authors.

Benz and Ludwig present two studies: Study 1 identifies subject-specific skills for dealing with digital data acquisition systems, Study 2 presents the development of a self-efficacy scale based on these skills. The handling of data acquisition systems is covered by one competence area in DiKoLAN. Based on this, competences for digital data acquisition systems in pedagogical laboratory situations are differentiated in more detail. Generalizing from TK to DK does not seem to be helpful in describing the use of highly specialized technologies/media such as digital data acquisition systems. Nevertheless, everyday digital experiences and the resulting strategies for dealing with digital applications and devices must be dynamically incorporated into teaching concepts, so that the relevance of digitization-related PCK in digital measurements should be considered in future work.

Baumann et al.'s teaching concept for the teaching of species knowledge in the ID-Nature project explicitly considers such skills and areas, which include sociocultural aspects in its design and objectives: the production and sharing of an identification app through participation in a large project with many others corresponds to central aspects of digitality and presupposes digitality-related pedagogical knowledge. Established forms of digital communication of standards in the peer group of students, such as posting their own digital products in social media (e.g., TicToc), are deliberately used in the classroom. Even with the existing subject specific digital competences of the TPACK model specified through DiKoLAN, it is difficult for teachers to develop such teaching concepts without raising awareness of the need to develop competences in the socio-cultural areas explicitly emphasized in the DPACK model.

Conclusion

Integrating the DPACK and DiKoLAN models into STEM teacher education offers a more advanced approach to developing digital literacies. The aforementioned studies extend previous research on DPACK and DiKoLAN. As the studies show, these models provide enhancements and extensions that allow for covering and emphasizing practice-relevant facets. However, it must always be considered, on a case-by-case basis, the extent to which each of these areas should be considered for specific levels of training, concepts, or accompanying research, as the increasing complexity can also be detrimental. Future reflections from practice will certainly provide experience in this regard.

Author contributions

JH: Conceptualization, Project administration, Writing – original draft, Writing – review & editing. TB: Conceptualization, Project administration, Writing – original draft, Writing – review & editing. CT: Conceptualization, Project administration, Writing – original draft, Writing – review & editing. SB-G: Conceptualization, Project administration, Writing – original draft, Writing – review & editing.

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Conflict of interest

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