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EINFÜHRENDER BEITRAG IN DEN THEMENSCHWERPUNKT

Digitization in teacher education—quality enhancement, status quo, and professionalization approaches

Charlott Rubach · **Iris Backfisch**

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Abstract This special issue brings together a diverse range of research that reflects the multifaceted landscape within the realm of digitization in teacher education. The contributions in this special issue range from underscoring how machine learning is not just an analytical tool but a beacon for identifying systemic challenges, i.e., dropouts and its impacts, and informing policy decisions within teacher education. They extend to contributions that bring to light the critical evaluation tools now at our disposal, which diagnose pressing issues in teacher education—such as the stagnation in digital competencies among (pre-service) teachers and their underestimation of digital media's potential. The findings of the present contributions also highlight a crucial point: the need to reshape curricula to embed digital competencies as fundamental pillars of teacher education. Moreover, they reveal the effectiveness of innovative strategies such as reverse mentoring, collaborative peer learning, and leveraging educator role models as catalysts for change. Together, this special issue acts as a compass, directing the course of teacher education to a tech-savvy and responsive future.

Keywords Digitization · Teacher education · Context, Input, Process and Product Evaluation Model

✉ Charlott Rubach
Institut für Schulpädagogik und Bildungsforschung, Universität Rostock, August-Bebel-Str. 28, 18055 Rostock, Germany
E-Mail: charlott.rubach@uni-rostock.de

Iris Backfisch
Tübingen Center for Digital Education, Universität Tübingen, Wilhelmstraße 31, 72074 Tübingen, Germany

Digital technologies change the daily lives of all of us and the professional routines of employees and employers (Arnold et al. 2016; Dengler and Matthes 2018). This technological wave cascades down to teachers, who bear the responsibility of not only integrating these technologies meaningfully into subject-specific teaching but also guiding students in developing crucial digital competencies. This complex requirement highly demands teachers' digital competences, which are often unmet (Eickelmann and Drossel 2020; Rubach and Lazarides 2023). That said, we have a gap between the demand for digitally competent teachers and the current capacities of teacher training (Fernández-Batanero et al., 2022; Herzig and Martin 2018; Lorenz and Endberg 2019). However, it is not sufficient to merely acknowledge the need for digitally competent teachers. Instead, the (teacher) education system must actively support and develop these competences. Thus, there is an effort to gain knowledge on how to support teachers' digital competence and understand the potentials and harms of digital transformation within teacher education (Knezek et al. 2023; Peters et al. 2022).

A systematic examination and adjustment of teacher training programs are necessary to ensure that these programs can impart the necessary digital competencies to future and current teachers. Addressing the systematic examination requires a collaborative effort across multiple disciplines (Spante et al., 2018; van Ackeren et al. 2019). As we stand at the crossroads of tradition and innovation, research becomes the compass that guides us through uncharted territories. With new research, we can answer compelling questions: How do we equip the educators of tomorrow for job roles that are yet to be defined? Can the digital transformation improve or quicken educational organization management of the complex teacher education system? Is the key to unlocking the potential of educational administration data-informed decision-making?

This special issue is dedicated to examining ongoing digital transformation and providing some insights into how teacher education can flourish from digital transformations. The special issue provides interdisciplinary impulses on the reshaping of teacher education—from the usefulness of monitoring processes within teacher education using innovative digital methodologies to the integration of technology in teacher preparation classes and from the investigation of complementary methods to assess the current status quo to the development of digital competence of preservice teachers. To systematically break down the complexity of teacher education, the Context, Input, Process, and Product Evaluation Model serves as our analytical lens, providing a structured framework to dissect and understand the impact of digital technologies on the end-to-end process of teacher education.

1 CIPP model as an approach to analyze digital transformation in teacher education

Within the German-speaking realms of education, a systematic evaluation is not just beneficial but essential to grasp the full extent of digital transformation's impact on the multifaceted teacher education system. For a systematical evaluation, we

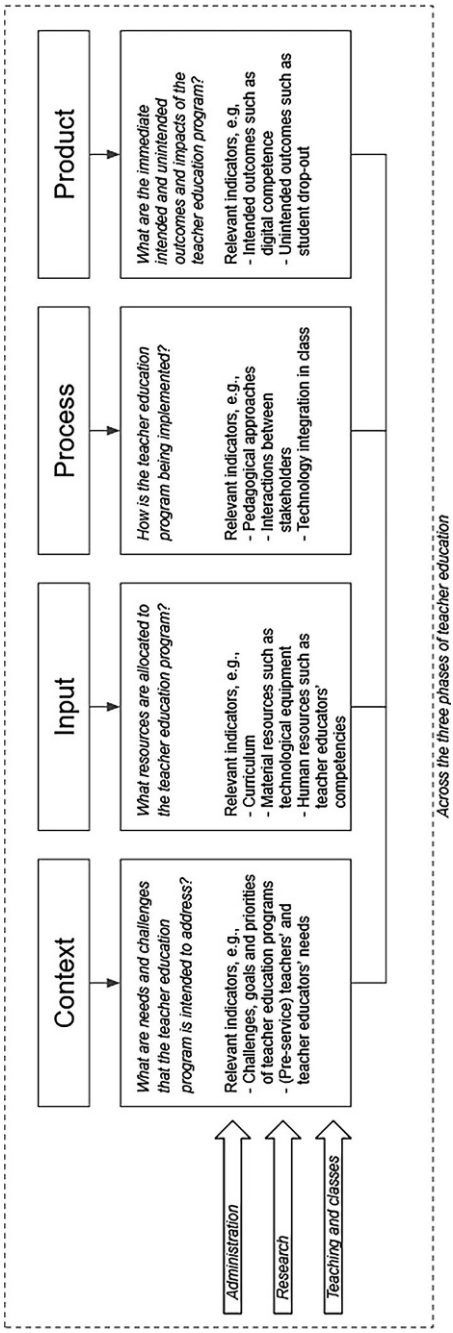

Fig. 1 The process of the evaluation across teacher education adapting the CIPP model

adapted the Context, Input, Process, and Product Evaluation Model (CIPP) (Stufflebeam 2003a, b) to teacher education. Initially developed in the 1960s, the CIPP Model guides systematic evaluation processes to investigate the effectiveness and efficiency of projects, programs, and policies steering decisions by policy boards or administrators (Stufflebeam 2003a). Used in school and teaching quality evaluation (see Döbert and Klieme 2010), the CIPP Model is now adapted to enhance teacher education in the digital era. Comprising four foundational pillars—context, input, process, and product—the model is a crucial framework for our investigation into enhancing teacher education for the digital future. Figure 1 illustrates how the CIPP model can help to ask questions that need to be answered to systematically evaluate the complexity of the teacher education system. The following chapter provides a synthesis of the current literature, setting the stage for exploring how such a systematic approach can advance our understanding and practice of teacher education in the midst of digital transformation, as discussed in this special issue.

Let us consider the *context* element first: it asks the fundamental question of what needs and challenges the program aims to address. It is about goals, needs, and current challenges (Stufflebeam 2003a, b). The aspiration of teacher education within digital transformation is two-fold: on the one hand, there is the drive to refine administrative processes in higher education utilizing digital innovation—consider the application of machine learning in learning analytics and the advent of digital credentials (Bertini et al. 2021; Scheidig and Holmeier 2021). On the other hand, there is the drive to adjust the curriculum and learning opportunities to address the pressing challenges associated with enhancing the digital competencies of (pre-service) teachers (Borukhovich-Weis et al. 2021; Max et al. 2023; Seidl & Michel 2021). Yet, we encounter hurdles, such as the disparity in standards for teacher education across federal states in Germany—a challenge not easily overcome, as evidenced by the slow curriculum adjustments in the face of digital advancements (Bernholt et al. 2023; Kammerl & Mayrberger 2014). It is hardly surprising that German teachers express a need for support in navigating the digital landscape of their profession (Rubach & Bonanati 2022).

Moving to the *input* element of the CIPP model, we examine the resources designated for the program. For teacher education, this means analyzing the intended curriculum, material resources available, and the human capital, such as the available knowledge and motivation of stakeholders like faculty and teacher educators. Research has zoomed in on two facets within the teacher education's input: curricular developments in digital teacher education and the digital competencies and motivational beliefs of pre-service teachers and teachers (Backfisch et al. 2020; Instefjord & Munthe, 2016; Quast et al. 2023). Findings point to a paradox: while technology and technology-enhanced learning are advertised, their importance in teacher training is rather low. Moreover, teacher educators feel underprepared to deliver such technology-enhanced learning experiences (Instefjord & Munthe, 2016; Lindfors et al. 2021), pointing to a scarcity of resources for preparing (pre-service) teachers. Other resources to be acknowledged as input are measurement instruments to access developing digital competencies among (pre-service) teachers. In the last decade, numerous instruments have been designed to measure the knowledge, skills, and motivational beliefs of digital competence in education (Lachner et al. 2019;

Rubach & Lazarides, 2021; Sailer et al. 2021; Schmid et al. 2020). Such instruments are critical in the *input* stage to understand and improve the outcomes of digital competence in teacher education.

The *process* element of the CIPP model then asks, 'How is the program being implemented?' Here we delve into the methods and procedures currently in play within the design of teacher education programs and training. Are pedagogical approaches within these programs effective in fostering digital competence (Howard et al. 2021; Knezek et al. 2023)? To what extent is digital media being harnessed in teacher education (Capparozza et al. 2023)? While there's an abundance of descriptive reports on strategies used within teacher education, empirical examination of their long-term significance remains sparse (Kaspar et al. 2020).

Finally, evaluating the *product*—the fourth pillar of the CIPP model—brings us to consider the effects of the teacher education program. What are the tangible and intangible outcomes? This stage is about the results of teacher education—measuring, interpreting, and appraising the outcomes through the prism of their short-term and long-term, intended and unintended impacts (Stufflebeam 2003a). Focus areas include the rise of digital competence among (pre-service) teachers and educators post-program (Starkey 2020), as well as the evaluation of digital transformation efforts within teacher education, i.e., results of automated administration processes in teacher education (Salas-Pilco & Yang 2022).

In conclusion, previous investigations have shed light on various facets and dynamics of digital transformation in teacher education. The application of the CIPP model illuminates these potentially influential factors, underscoring the multifaceted and complex nature of digital transformation in teacher education. It is imperative that all or at least multiple elements of the CIPP model—context, input, process, and product—are viewed as interconnected and not isolated. This special issue bridges the divide by presenting current research from diverse perspectives and methodological approaches, tying together the different pillars of the CIPP model within single papers for a holistic view of the digital transformation in teacher education. By dissecting the context, input, process, and product of teacher education, this issue not only stresses the importance of intermediary elements but also presents a practical roadmap for program enhancement and the achievement of educational goals related to digital transformation within teacher education systems.

1.1 Goals of the special issue

This special issue assembles pioneering insights from renowned experts delving into the digital transformation of teacher education. Showcasing seven contributions, it navigates through three thematic areas, triangulating the context, input, process, and product of teacher education. The following questions navigate the three thematic areas:

- **Evaluating the context and input of digital transformations within teacher education:** How does Learning Analytics redefine our understanding of teacher education systems, and what roles do new measurement instruments play in this advanced monitoring? For instance, Scheidig and Holmeier have utilized machine

learning processes to predict dropouts of pre-service teachers with remarkable accuracy, offering a tool for quality enhancement in teacher education. Vejvoda, Stadler, Schultz-Pernice, Fischer, and Sailer present a validated self-assessment tool, charting a course from mere technological proficiency to a reflective understanding of digital impact.

- **Evaluating the input and process of digital transformations within teacher education:** What are the implications of the evolving motivational beliefs of pre-service teachers and teachers in using digital media for teaching processes, and how do educational and human inputs translate into transformative teaching processes? Empirical explorations by the author groups Rubach, Quast, Porsch, and Arndt as well as Bertram, Baier-Mosch, Dignath, and Kunter unveil the nuanced dynamics between belief systems, technology usage and educational support, advocating for comprehensive competence development in teacher training. Backfisch, Franke, Ohla, Scholtz, and Lachner spotlight the ambiguity of diverse group compositions in elevating the quality of lesson planning.
- **Evaluating the process and product of digital transformations within teacher education:** How do pre-service teachers' digital competence develop, and what are the implications for innovations within teacher education? The articles by Johnson, Schneider, and Müller as well as Schiefner-Rohs and Krein challenge us to rethink program designs as they reveal shifts in teachers' beliefs about technology, advocating for a curriculum more attuned to the digital realities of classrooms.

In summary, the special issue acts as a compass, directing the course of teacher education to a tech-savvy and responsive future. Contributions in this special issue underscore how machine learning is not just an analytical tool but a beacon for identifying systemic challenges, i.e., dropouts and its impacts, and informing policy decisions within teacher education. Also, included contributions bring to light the critical evaluation tools now at our disposal, which diagnose pressing issues in teacher education—such as the stagnation in digital competencies among (pre-service) teachers and their underestimation of digital media's potential. The findings also highlight a crucial point: the need to reshape curricula to embed digital competencies as fundamental pillars of teacher education. Moreover, they reveal the effectiveness of innovative strategies such as reverse mentoring, collaborative peer learning, and leveraging educator role models as catalysts for change.

Together, we hope this special issue piques your curiosity and serves as a stimulating resource for your own reflections on the digital transformation of teacher education.

Charlott Rubach & Iris Backfisch

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Conflict of interest C. Rubach and I. Backfisch declare that they have no competing interests.

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