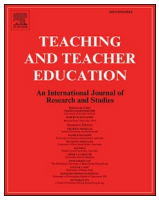
Teaching and Teacher Education 167 (2025) 105224

Contents lists available at ScienceDirect

Teaching and Teacher Education

journal homepage: www.elsevier.com/locate/tate



Research paper

Exploring conditional factors in digital instructional development: Insights from qualitative interviews with German teachers

Lisa Matuschek *, Tobias Hackenberg

Institute of Human Resource Education and Management, LMU Munich School of Management, Germany

ARTICLE INFO

Keywords:
Instructional development
Digital technology
School development– school autonomy
Interview study

ABSTRACT

This study explores the conditional factors (CF) influencing the digital instructional development (ID) of teachers in Germany. Using qualitative semi-structured interviews with 35 teachers, this research provides a holistic examination of how CF – including competencies, attitudes, cooperation, digital equipment, and professional development – affect various phases of the ID process. Findings reveal that these factors are interconnected and impact each phase differently, particularly highlighting the challenges of time constraints and digital literacy. The study emphasizes the importance of school autonomy, supportive leadership, and targeted professional development in enhancing digital ID, ultimately fostering effective, modern teaching practices.

1. Introduction

Teachers today face the challenge of a dynamic and rapidly changing technological environment (Delcker & Ifenthaler, 2021). Innovations such as artificial intelligence (AI) are fundamentally changing entire areas of society and require adapted knowledge and skills from the people concerned (Dwivedi et al., 2021). This change poses major challenges for the educational system, but offers many opportunities to improve and individualize learning at the same time (Knight et al., 2023). Digital technologies enable new didactic approaches, facilitate access to extensive educational resources and promote collaborative learning (Haleem et al., 2022). However, an international comparison reveals that Germany trails in the digitalization of education. This disparity is highlighted in the latest Programme for International Student Assessment (PISA) study, which reveals that German students perform only moderately in utilizing digital technologies compared to their international counterparts (Lewalter et al., 2023). Furthermore, the incorporation of digital technologies by teachers in German classrooms remains considerably below the international average, as seen in PISA findings (Lewalter et al., 2023).

Nevertheless, there are various goals and measures for the digital transformation of schools set by education policy institutions, aiming for an improvement of present teaching and learning methods to catch up (Bundesministerium für Bildung und Forschung, 2023; Kultusministerkonferenz, 2017, 2021). Comparable to the Anglo-American area, in Germany the individual schools and, in particular, teachers are primarily responsible for the concrete implementation of the stated goals and measures (Krzychała, 2020; Rolff, 2023). To this aim, schools formulate school development (SD) strategies as a framework for innovations (Helmke, 2022; Rolff, 2023). For a successful integration of digital technologies and thus an improvement in teaching, the existing lessons must be redeveloped or further developed by teachers continuously. In this paper, this process of developing and implementing digital teaching methods (referring to technology integration in classroom settings) is denoted as digital instructional development (ID). With our qualitative interview study, we want to gain deeper insights from teachers into how they perceive the conditional factors (CF) associated with a digital ID.

1.1. Research on conditional factors influencing digital instructional development

Research has identified various CF influencing digital ID, including personal, school-related, and external conditions (Anthony & Clark, 2011; Caspari-Gnann & Sevian, 2022; Chaharbashloo et al., 2020). A key focus has been the integration of digital technologies, which significantly impact teachers' instructional practices.

School administrators play a crucial role in fostering a collaborative culture that supports professional growth and provides resources for innovative teaching (Campbell, 2020; Hernández-Romero & Sun, 2021). Furthermore, school administrators are essential for establishing an environment conducive to teacher cooperation, innovation, and ongoing

* Corresponding author.
E-mail address: lisa.matuschek@lmu.de (L. Matuschek).

https://doi.org/10.1016/j.tate.2025.105224
Received 22 November 2024; Received in revised form 29 August 2025; Accepted 12 September 2025
Available online 19 September 2025

enhancement of instructional strategies, ultimately improving student learning outcomes (Hallinger & Kovačević, 2019; Leithwood et al., 2019).

Several studies have also looked at how teacher cooperation itself affects instructional design (ID). This cooperation can vary in how intense or deep it is. For example, it can range from simply sharing information, to dividing up tasks, to truly working together in a co-constructive way. This last type — co-constructive cooperation — involves actively collaborating and is considered especially effective for creating innovative instructional designs (Compagnoni et al., 2024; Gräsel et al., 2006). However, the study of Hartmann et al. (2021) on teacher cooperation for developing new educational concepts illustrates that activities related to co-construction are relatively rare among teachers, whereas informative exchanges occur more frequently.

Professional development significantly affects instructional quality, depending on factors like teacher experience and program structure (Dulo, 2022). In response to these findings, educational leaders, including school administrators and local governments have recommended revisiting the relationship between professional development activities and instructional quality by offering targeted training (Dulo, 2022). Further research suggests that aligning professional development programs with school administrations regulatory focus can foster innovative teaching, providing practical insights for enhancing teaching practices (Liu & Zhang, 2024). Successful professional development programs are characterized by active learning, cooperation, reflection, and comprehensive, long-term engagement. However, the effectiveness of these programs is influenced by contextual factors within schools, which can either support or restrain progress. Striking a balance between school ambitions and realistic expectations is critical for program success (Langelaan et al., 2024). Teachers' concepts of instruction are shaped by the affordances and constraints of their classroom environments, as well as broader educational contexts. Effective professional development must emphasize pedagogical tensions, promote practice-oriented designs, and adapt academic concepts to the realities of classroom teaching (Barak, 2024).

In the traditional view, learning is seen as the passive reception of knowledge transmitted by teachers, whose role focuses on subject mastery and delivery (Gargallo et al., 2011; Kim et al., 2013; Alt, 2018). In contrast, the constructivist approach redefines teaching as a facilitative process, emphasizing active student engagement in constructing, organizing, and reflecting on knowledge. This shift assigns students a more autonomous role as self-directed learners and evaluators, while teachers guide discovery, collaboration, and critical thinking (Gargallo et al., 2011; Kim et al., 2013; Alt, 2018). Compared to the traditional model, the constructivist approach is considered more effective in fostering deeper understanding, transferable skills, and sustained motivation. Moreover, the integration of technological resources in classrooms is more strongly associated with constructivist teaching, as teachers often plan and implement technology use from this pedagogical perspective — especially when influenced by their own personal-professional engagement with technology (Almerich et al., 2024). Research also shows that both in-service and pre-service teachers tend to endorse constructivist beliefs about teaching and learning more than traditional beliefs. However, while instructional planning often reflects a balance between these approaches, in-service teachers tend to revert to traditional practices once they change from theory to practice. This underscores the importance of designing professional development that supports teachers in maintaining constructivist approaches in real-world instructional settings (Lui & Bonner, 2016). However, teachers — particularly veteran educators — face challenges in adopting educational technology. A longitudinal analysis of these challenges suggests that as such barriers are addressed, teachers become more committed to integrating technology into their practice. This highlights the need to reshape professional learning, focusing on the cultural and political aspects of technology use in education (Orlando, 2014).

Moreover, studies indicate a strong correlation between teachers' competence-related beliefs regarding differentiation and empowerment of learners and the reported use of technologies to enhance instructional quality (Runge et al., 2023). Many educators view digital ID as a significant opportunity to make learning more interactive and engaging, thereby increasing student motivation. Digital technologies allow for the customization of learning experiences and promote collaborative learning processes, aspects frequently emphasized by teachers with positive experiences using digital technology (Haleem et al., 2022). Furthermore, it has been shown that if there is a sufficient level of digital technology in schools, then teachers' basic digital skills are a crucial factor for its use (Sailer et al., 2021).

1.2. Research purpose

Despite the numerous studies, examining the CF existing literature presents a rather distinct perspective on the CF influencing digital ID. Current research has yet to comprehensively examine or empirically substantiate their interactions. The literature review suggests that various technological, pedagogical, and institutional conditions shape digital instructional strategies; however, the precise nature of their interdependencies remains insufficiently explored. This gap in research highlights the need for a more systematic and in-depth investigation into how these factors interact and collectively influence the effectiveness and sustainability of digital ID.

Furthermore, the various CF examined in previous literature appear to support ID in different ways, but they may also act as restraining factors if they are not sufficiently established. Furthermore, different CF seem to be relevant at different phases of the ID process and should be considered from a broader perspective. The continuous development of instructions are indispensable for educators today. The digital transformation and ongoing innovation make this topic more relevant than ever, affecting a wide range of teachers regardless of the current state of digitalization in schools or their instructional practices (Helmke, 2022). Hence, this study aims to examine the influence of CF on the process of digital ID. Therefore, we are using a holistic view, including different phases of the process of ID, influenced by different CF.

This enables us to investigate these possible relationships of CF at different phases of the ID process, using semi-structured interviews with German teachers (King et al., 2018)

With our qualitative content analysis, we address the following research questions.

(1) Which conditional factors regarding digital instructional development (digital ID) are perceived by teachers?
(2) How do the identified factors affect the process of digital instructional development?

2. Conceptual framework

School development (SD) encompasses all systematic strategies aimed at enhancing school and classroom learning, as well as student achievement (Hopkins et al., 2014; Maag Merki, 2020). It occurs at the individual school level, driven by the initiatives of school administrations and teachers (Rolff, 2023). In Germany, SD traditionally focused on organizational aspects but has increasingly aligned with the Anglo-American student-oriented approach, emphasizing school autonomy (Hopkins et al., 2014).

SD comprises three interrelated dimensions: (a) organizational, (b) instructional, and (c) staff development (Maag Merki, 2020; Rolff, 2023). Organizational development involves school-wide change initiated internally by teachers and administrators, fostering collective learning (Rolff, 2023). Teachers' active participation in planning strengthens their commitment to reform. Instructional development (ID) focuses on student-centered improvements, refining teaching methods through new strategies and technologies (Klippert, 2003; Rolff, 2023). Staff development enhances teachers' professional and personal

competencies through training and continuous development, recognizing their central role in educational success (Rolff, 2023).

2.1. Instructional development models

As mentioned above, ID is crucial for the direct implementation of new teaching strategies and innovations (Helmke, 2022; Klippert, 2003). To structure this rather complex process and help teachers to successfully improve their instructions, a variety of ID models has been formulated (Gustafson et al., 1998; Morrison et al., 2017, pp. 77–89; Dick & Reiser, 1995). Therefore, it is constructive to base the analysis on an overarching ID model. According to Lim and Chai (2008), successful ID models emphasize that teachers have to re-examine their existing practices and the constraints and uncertainties which come with the integration of technologies. In our analysis, we use Helmke's (2022) sequence model of ID. This model provides a comprehensive overview of the ID process from the teacher's perspective — rather than an organizational perspective — by addressing different phases of ID, including potential obstacles. Additionally, the model is enriched by different CF that influence the success of instructional design (Helmke, 2022). This approach allows us a deep examination of ID, emphasizing the pivotal role of teachers and the crucial factors that are relevant for the effectiveness of instructional strategies.

2.1.1. Basic sequence of lesson development according to Helmke (2022)

Helmke's (2022) process of ID is systematically divided into five distinct phases (Fig. 1). Though the model appears linear, it does not have to be followed rigidly and has a more spiral-shaped rather than linear path.

The basic sequence of ID starts with the 'information' teachers receive. This information phase is about current teaching quality and can be derived from a variety of sources, such as teacher training, scientific articles, colleagues or students. After receiving the information, the 'reception' begins. The information is recorded and evaluated by the teacher. Crucial in this context is the quality of both content and form, as well as clarity, relevance, timeliness, and accuracy of the information. This depends on whether the information is recorded correctly by the teacher and if the teacher values the information as important for their teaching actions. In the following 'reflection' phase, the teacher can relate the information relevant to them to their own lessons. This is followed by further consideration of possible changes and consideration of changing one's own teaching actions. The phase of 'action' is determined by converting intended behavior into real behavior. The teacher invests resources to integrate ideas and concepts into lessons and to acquire the necessary skills for implementation. In the phase of the 'evaluation', the newly developed instructions are assessed for their effectiveness and efficiency, focusing on the students' learning success. Depending on the results of the evaluation, a further development process can be initiated, or it can lead to the development attempt being rejected if the expected success does not occur.

2.1.2. Conditional factors of instructional development

The basic sequence of ID is enriched by CF. Fig. 2 shows the entire sequence model of ID, supplemented by the CF.

This model of ID highlights two types of CF that influence teaching and learning: individual and external (Helmke, 2022, p. 295). Individual conditional factors pertain to the personal attributes of teachers. This includes their pedagogical skills, subject knowledge, attitudes, and beliefs, such as their enthusiasm and ability to manage classrooms effectively. External conditional factors, on the other hand, refer to the broader environment that influences the educational process. They also extend to the school environment, including leadership, available resources, and the institution's overall climate and culture. Beyond the school, systemic conditions such as educational policies, curriculum frameworks, and societal expectations play a significant role in shaping instructional goals and methods. Helmke's (2022) model emphasizes the interplay between these factors, suggesting that teachers must navigate and adapt to these conditions to maximize learning outcomes. These CF were used to derive the main categories of competencies and attitudes, professional development, cooperation, digital equipment, framework conditions and extrinsic incentives, which are used in our study for digital ID.

3. Method

3.1. Data Collection

The objective of our study was to attain holistic insights into the processes of digital ID. To achieve this, we conducted semi-structured interviews, a widely recognized qualitative research method that allows for in-depth exploration of participants' perspectives while maintaining a flexible yet systematic approach (Ruslin et al., 2022). The target population for our study includes German teachers at different school types, teaching different subjects and with different levels of work experience. Participants were recruited through the authors' professional network, aiming for a representative sample of German teachers regarding age, work experience, subjects, school type (Bosch-Stiftung, 2023, p. 7). They were contacted via email, and participation was voluntary. Interviews were either held in person or online (via Zoom), based on interviewee preference. The average duration of the interviews is 42 min. All interviews were recorded, with interviewee consent (Mayring, 2014). The interviewers used open-ended questions to facilitate an in-depth conversation. At the beginning, participants were asked questions regarding their understanding of digital ID. The remaining questions were structured according to the CF of competences and attitudes, framework conditions, digital equipment, cooperation, professional development and extrinsic incentives. A selection of the interview guide with the lead questions is shown in Appendix A. At the end of each interview, some demographic and research related questions (gender, age, school type, subjects taught, work experience, satisfaction with digital equipment) were asked. In total, we had 1480 min of recorded data available.

3.2. Sample

The final sample of teachers comprised $N = 35$ teachers with 62.9 % female and 37.1 % male. The average age of the teachers surveyed was $M = 41.31$ years ($SD = 11.98$; min = 24, max = 63); the aim was to reach a broad age range to be able to identify different experiences with digital ID. Work experience after the preparatory service ranges from 1 to 38 years with an average work experience of $M = 12.67$ ($SD = 10.87$) years. Of the teachers surveyed, 9 (25.7 %) teach at primary schools, 11 (31.4

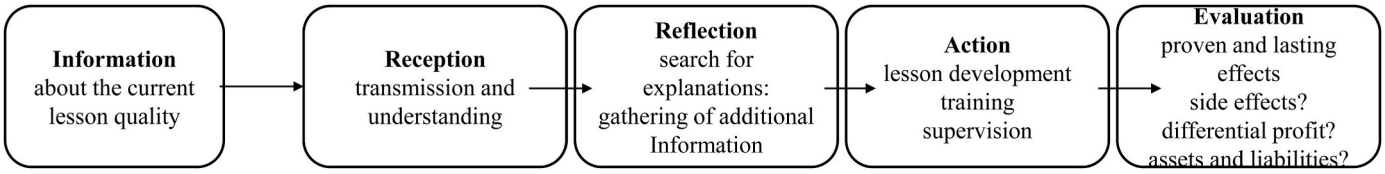


Fig. 1. Basic sequence of instructional development
Note. Linear represented sequence model of instructional development. Based on A. Helmke, 2022, p. 295.

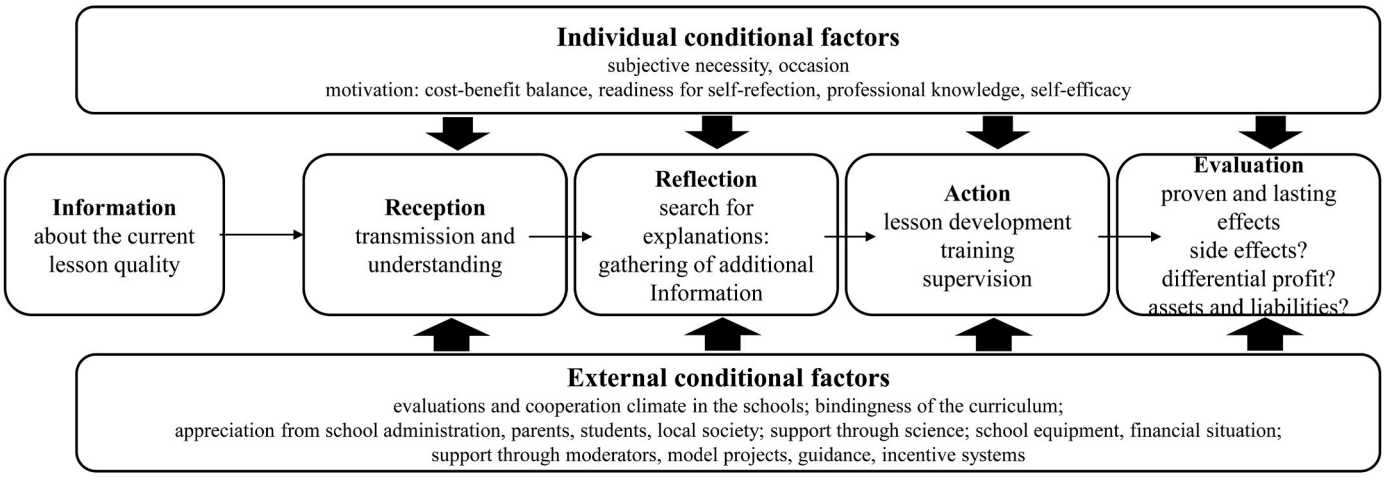


Fig. 2. Sequence model of instructional development with conditional factors
Note. Linear represented sequence model of instructional development with individual and external conditional factors. Based on A. Helmke, 2022, p. 295.

%) at general secondary schools, 12 (34.3 %) at vocational schools and 3 (8.6 %) at schools for children with special needs. Table 1 presents a sample description categorized by school types. Our sample reflects real demographic data of teachers well (Bosch-Stiftung, 2023, p. 7). The teachers included in the sample lecture a wide range of subjects, from German and English to mathematics and science, as well as vocational subjects such as business administration and wood technology.

3.3. Data analysis

The interviews were analyzed using the method of qualitative content analysis (Mayring, 2021) and the data analysis software MAXQDA 2024. Our goal was to observe CF in a rather cohesive than separate way, based on the theoretical ID model (Helmke, 2022). Using a deductive-inductive approach, our initial goal was to structure the interview material according to theoretically developed CF and investigate them more deeply. The second step was to identify which stages of the ID process (according to Helmke (2022)) were mentioned and how these CF influence the process of digital ID. Using content analysis aligns with a deductive-inductive approach by systematically applying theoretical categories while allowing empirical refinement. This ensures methodological rigor and transparency. In contrast, thematic analysis (Braun & Clarke, 2006) primarily follows an inductive logic, making it less suited for balancing theory-driven and data-driven analysis.

The first $n = 20$ interviews were independently coded by two coders based on predefined main categories (CF), further refined into deductively-inductively derived sub-categories (Table 2). Segments could be double-coded when relevant to multiple CF. Intercoder reliability was high for main categories ($\kappa = .81$) and sub-categories ($\kappa = .78$) (Landis & Koch, 1977). Discrepancies were resolved through coder consensus. The remaining $n = 15$ interviews were randomly distributed and coded independently. Overall, for our 6 main categories and 3–8 sub-categories per category resulted in N = 1492 coded segments (Table 2).

In a subsequent analysis step, all segments were assigned to the five phases of the instructional development (ID) process (Helmke, 2022) and evaluated as supportive, restraining, or bidirectional concerning ID. A comprehensive coding guide with definitions and anchor examples is presented in Appendix B. An illustrative example (Fig. 3) demonstrates this two-step coding: an initial assignment to the main category 'equipment' and sub-category 'benefits of digital equipment', followed by placement in the 'action phase' as supportive, given the teacher's active tablet use promoting student motivation. Ambiguous cases were consistently resolved through close collaboration between coders. The following section integrates these findings from both coding steps.

Table 1
Summarized presentation of conditional factors.

	n		*n*		*n*
Competencies & attitudes		**Professional development (PD)**		**Cooperation**	
Differences within the college	82	Supply and demand of PD	91	General exchange	96
Open-mindedness towards digitalization	75	Structure of PD programs	64	Benefits of cooperation	61
Student orientation	45	Content of PD programs	58	Co-constructive cooperation	41
Skepticism toward digitalization	39			No cooperation	21
Digital literacy	36				
Personal benefits	33				
Ability to reflect	23				
Digital equipment		**Framework conditions**		**Extrinsic incentives**	
Challenges of digital equipment	127	Students	93	Time resources	19
Change in equipment	121	School administration	70	Performance evaluation	17
Benefits of digital equipment	56	Educational institutions	59	Student performance	8
Cooperation tools	16	Curriculum & regulations	43		
		Lack of time	40		
		Parents	26		
		Covid-19 pandemic	20		
		Companies	11		

Note. Main conditional factors derived from literature (Helmke, 2022) and enriched by insights from the interviewees. Total number of codings $N = 1492$.

4. Results

4.1. Identified conditional factors and their underlying facets

Our research aimed to explore the impact of various facets of CF on the process of digital ID.

First, we organize our results according to the categories and subcategories related to Helmke's (2022) model of ID, summarized in Table 1.

Table 2
Sample description divided by teachers' school types.

School type	*n*	Gender		Age				Work experience			
		Female	Male	*M*	*SD*	Min	Max	*M*	*SD*	Min	Max
Primary Schools	9	8	1	35.67	15.47	24	63	9.33	13.56	1	38
General secondary schools	11	8	3	41.73	9.86	30	59	13.41	10.07	3	31
Vocational schools	12	3	9	43.50	10.37	31	61	12.42	8.81	6	30
Schools for children with special needs	3	3	0	48.00	12.77	34	59	21.00	13.45	6	32
Full sample	**35**	**22**	**13**	**41.31**	**11.98**	**24**	**63**	**12.67**	**10.87**	**1**	**38**

Note. Work experience given in years after accomplishing initial teacher training.

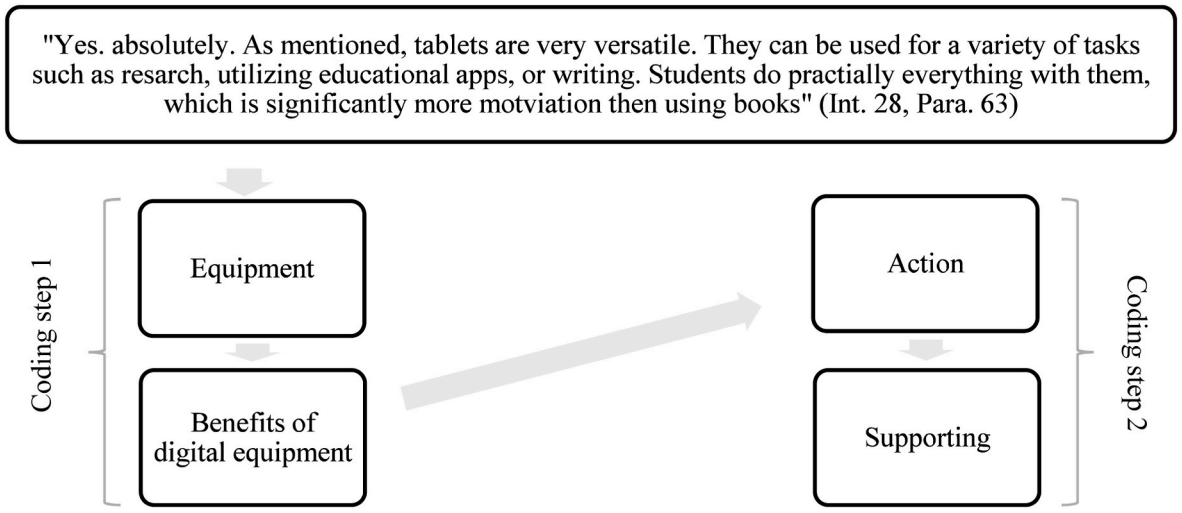


Fig. 3. Example of the two-step coding process [1]
Note. The first coding step involved assigning facets of contextual factors (CF). In the second coding step, we categorized the phases within the instructional development (ID) process and identified the influence of CF, whether it was supportive, bidirectional, or restraining, allowing for multiple codings ($N = 1492$). Statements were translated from German to English.

[1] All direct quotations from the interviews were translated from German into English by the authors. The information in brackets refers to the quoted interview and paragraph.

4.1.1. Individual CF

Teacher 'competencies and attitudes' play a crucial role in digital ID. The sub-category *open-mindedness towards digitalization* ($n = 75$) reflects a positive attitude essential for embracing innovation, while *skepticism toward digitalization* ($n = 39$) reveals potential resistance. The *ability to reflect* ($n = 23$) is essential for teachers to refine instructional practices. *Differences in competencies and attitudes within the college* ($n = 82$) further highlights variability in digital adaptation.

Teachers emphasize *digital literacy* ($n = 36$) as a fundamental competency for effective digital ID. Additionally, they aim to design instructions in a *student-oriented* ($n = 45$) and modern manner, aligning with students' digital proficiency. *Personal benefits* ($n = 33$), such as improved teaching efficiency, are also recognized as motivators for digital integration.

4.1.2. External CF

In examining the role of 'professional development' for digital ID, several key factors emerge. The alignment between the *supply and demand of professional development* ($n = 91$) and the *structure of professional development programs* ($n = 64$) underscores the importance of matching available professional development opportunities with the needs of teachers. The *content of professional development programs* ($n = 58$) further highlights the importance of equipping teachers with the necessary digital skills to foster instructional innovation. This targeted training is essential for fostering instructional innovation and enhancing the overall effectiveness of digital integration in the classroom.

'Cooperation' is another key element in digital ID. The *benefits of cooperation* ($n = 61$) and *co-constructive cooperation* ($n = 41$) support instructional innovation, while *no cooperation* ($n = 21$) reflects challenges in digital integration due to limited collaboration. The majority of teacher report *general exchange* ($n = 96$) as their main type of cooperation.

The availability and evolution of 'digital equipment' significantly impact digital ID. *Changes in digital tools over time* ($n = 121$) presenting both *challenges* ($n = 127$) and *benefits* ($n = 56$) emphasizing the need for continuous professional development and institutional support. In addition, *cooperation tools* ($n = 16$) that facilitate teacher exchange and communication were mentioned.

'Framework conditions' reflect external influences of various stakeholders on digital ID, including *students* ($n = 93$), *school administration* ($n = 70$), *educational institutions* ($n = 59$), *parents* ($n = 26$), and *companies* ($n = 11$). Alongside the influence of these stakeholders, the *lack of time* ($n = 40$) is a major constraint, as teachers balance multiple responsibilities. Teachers frequently express critical views of existing curricula and regulations ($n = 43$), particularly in relation to digital instructional design (ID). A key point of concern is the limited integration of digital technologies in assessment practices, where traditional exam formats still dominate, leaving little room for innovative or

technology-enhanced approaches. This perceived rigidity is seen as a barrier to advancing digital ID. Additionally, the experiences gained during the COVID-19 pandemic (n = 20) are highlighted by teachers as significant contextual factors. These experiences are largely viewed as catalysts for innovation, having fostered greater familiarity with digital tools and increased openness toward integrating technology into teaching practices.

The least frequently mentioned CF is 'external incentives'. Teachers see both the *success of their students' performance* ($n = 8$) and the *performance evaluation of their teaching* ($n = 17$) by others (e.g. school administration or colleagues) as external incentives to further develop their instructions. They also express the need for additional *time resources* ($n = 19$) respectively compensatory hours to support their digital ID projects.

4.2. Impact of conditional factors on digital instructional development

The second objective to deepen our understanding of the perceived CF was to allocate them to the digital ID process. This enables us to deduce how and in which phases the CF affect the process of digital ID. Fig. 4 shows the main CF related to the process of digital ID. The different lines represent the impact of the CF on the different phases of the ID process. The respective endpoints provide information about the frequency of mentions by the teachers surveyed. A detailed breakdown of the codes for the various phases of digital ID can be found in Appendix C.

As a reading example for Fig. 4, in the upper right corner, the CF of 'cooperation' is described in detail. The networks illustrate the categories of the Helmke model, while the corner points represent the phases of the process. The various lines and geometric shapes indicate the number of coded statements. In this context, circles reflect supporting statements, triangles represent bidirectional statements, and stars denote restraining statements.

The graphic illustrates that 'cooperation' has a significant supporting influence (marked by the dot-shaped line) during the digital ID phases 'reflection' and 'action'. However, the bidirectional influence (marked by the triangle-shaped line) is less pronounced in these phases compared to the 'reception' phase. Additionally, it is evident from the graphic that the restraining influence (marked by the star-shaped line) of 'cooperation between teachers' remains minimal across all phases of the digital ID process.

Moreover, it can be deduced that the factors 'competencies & attitudes', 'professional development' and 'cooperation' are seen as highly supportive in the phases of 'reflection' and 'action' by the teachers. In contrast, the teachers surveyed see many restraining facets in the factors of 'digital equipment' and 'framework conditions' in the early phases ('reception' and 'reflection' phase) of the digital ID process. This changes to a more supportive view in the later phases ('action' and 'evaluation' phase). The CF 'extrinsic incentive' is the least frequent mentioned CF and has a restraining influence especially in the 'reflection' phase. In the following section, the CF are examined in greater detail, with a focus on the most salient sub-categories and their influence on the digital ID process.

4.2.1. Competences and attitudes

The CF of the teachers' competences and attitudes are conducive to rethinking ('reception' and 'reflection' phases) existing teaching as well as the actual implementation of new digital teaching attempts ('action' phase) (Figs. 4 and 5). Especially a certain openness for digital technologies and new teaching methods proves to be particularly beneficial for the whole digital ID process (Int. 3, Para. 28; Int. 11, Para. 28; Int. 33, Para. 79).

However, skepticism towards digital technology is a corresponding hindrance to the digital ID process (Fig. 5). This skepticism can lead to end the ID process in the 'reflection' phase and therefore no new digital teaching attempts are tested and implemented (Int. 28, Para. 69). The implementation of digital technologies is restrained by teachers' initial resistance, exemplified by attitudes such as:

> I don't engage with that kind of technology because I simply have no use for it. I don't make use of such tools in my personal life, and I have no intention of incorporating them into my regular teaching or school-related tasks either. (Int. 7, Para. 107).

Hence, some teachers demonstrate complete resistance to new technologies and innovations, refusing to incorporate them into their teaching practices. (Int. 23, Para. 64, 74; Int. 31, Para. 72; Int. 34, Para. 140). The commonly mentioned reason for this resistance is the age of the colleagues, which correlates with a longer familiarization period required for new technologies due to less prior experience and a lower perceived benefit from the innovations, given the limited remaining working time (Int. 18, Para. 18; Int. 29, Para. 110). Nevertheless, the majority of teachers mentioned a high level of willingness to work with digital technologies and emphasize the relevance of sufficient digital competences (Int. 2, Para. 35; Int. 26; Para. 59).

4.2.2. Professional development

The condition factor of professional development can be seen as overall conducive to 'reflection' and 'action' within the ID process (Fig. 4). The structure of the training programs helps to ensure that teachers subsequently apply the content they have learned in their own teaching (Int. 5, Para. 94; Int. 15, Para. 120, Int. 35, 154). A substantial amount of practical work, coupled with numerous opportunities for experimentation, is regarded as beneficial by the teachers (Int. 23, Para. 111). Most teachers also report, and value internal school training courses offered by colleges (Int. 9, Para. 136; Int. 16, Para 87). Here, teachers have the opportunity to disseminate the knowledge acquired during professional development to their colleagues (Int. 19, Para. 59). Recently, a teacher posted that,

> There is a noticeboard where a colleague, for example, shares their expertise. Recently, someone came along and said, 'I'll do something on ChatGPT for half an hour – who's interested?' You can then add your name to the list and attend the session to hear what the colleague has to say, as they simply give a presentation. (Int. 8, Para. 72)

These training courses serve as a multiplier of new ideas and approaches and thus promote their implementation in the classroom. However, not all training courses meet this requirement, particularly in vocational schools where there is significant heterogeneity in the curricula (Int. 21, Para. 125; Int. 23, Para. 62). Even though training courses are generally viewed positively in terms of their contribution to digital ID (see Fig. 6), and teachers exhibit flexibility in their selection, the issue of time resources frequently arises. This challenge is evident both in terms of attending the training courses and in the subsequent implementation of the acquired knowledge into their own teaching, which imposes an additional time burden (Int. 1, Para. 23; Int. 24, Para. 92; Int. 29, Para. 168).

4.2.3. Cooperation

Cooperation is a crucial factor in the implementation of digital teaching methods. Hartmann et al. (2021) emphasize that co-constructive teacher collaboration is essential for successful ID. Direct cooperation, where teachers actively collaborate on instructional strategies, facilitates concrete action in the ID process. In contrast, general exchanges — where teachers share and evaluate ideas — primarily support the early stages of digital ID (Int. 2, Para. 91; Int. 6, Para. 72; Int. 22, Para. 108; Fig. 7). Teachers recognize cooperation's benefits, including problem-solving, feedback, and time efficiency (Int. 10, Para. 100; Int. 25, Para. 75; Int. 27, Para. 107). However, isolation remains a challenge, making collegial exchange essential (Int. 12, Para. 52) visible in this quote:

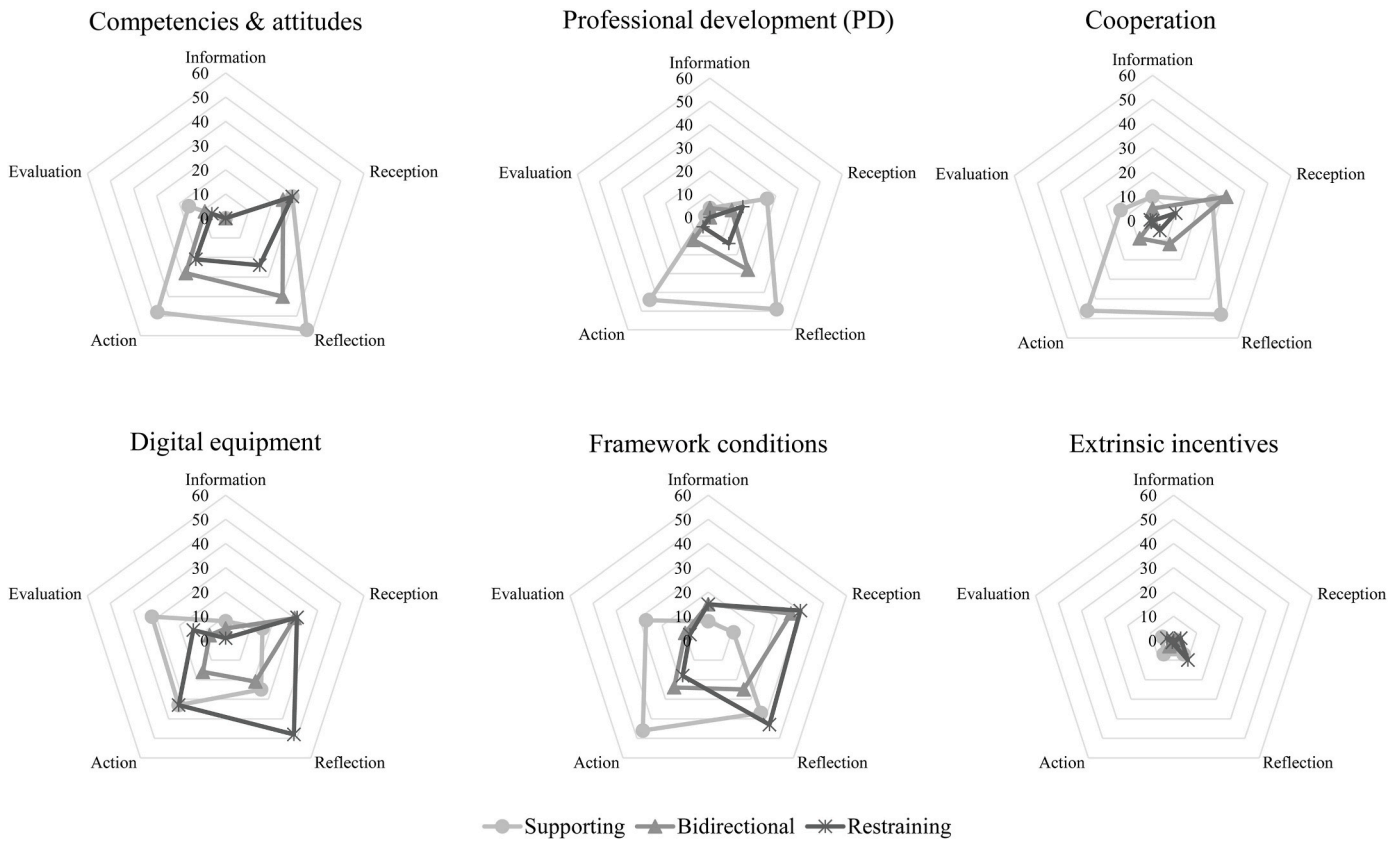


Fig. 4. Influence of conditional factors on process of digital instructional development
Note. Number of codings: Competencies & Attitudes $n = 332$, Professional Development $n = 213$, Cooperation $n = 219$, Digital Equipment $n = 321$, Framework Conditions $n = 363$, Extrinsic Incentives $n = 44$. The number of codings for the ID phases can be found in Appendix C.

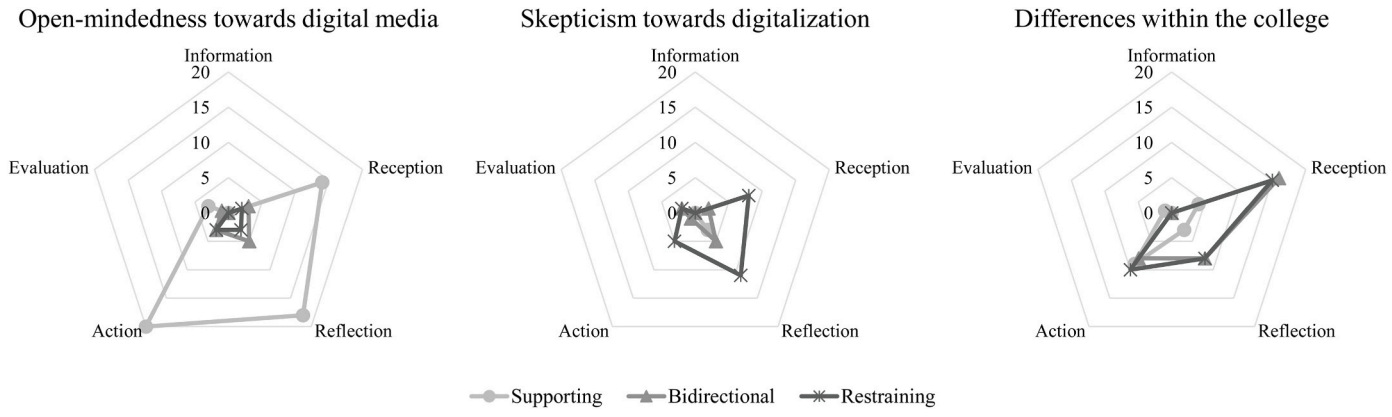


Fig. 5. Selected sub-categories of the main category 'Competencies and attitudes'
Note. Number of codings: Open-mindness towards digital media $n = 75$, skepticism towards digitalization $n = 39$, differences within college $n = 82$. The number of codings for the ID phases can be found in Appendix C.

> It certainly also depends on the teachers themselves, as there is still this mindset of working in isolation. Additionally, data protection regulations often play a role, causing fears that sharing preparation materials online might violate privacy laws. However, there also needs to be a culture of exchange established within schools and between schools. (Int. 14, Para. 31)

Formal evaluations of digital instructional practices by school administration or colleagues, such as classroom observations, are rare (Int. 8, Para. 82; Int. 11, Para. 87) but critical for quality assurance (Huber & Skedsmo, 2016).

4.2.4. *Digital equipment*

Teachers perceive digital school equipment as a constraint on the digital ID process, often leading to abandonment in the early planning phases ("reception" and "reflection") or during implementation ("action") as seen in Fig. 8. The primary challenge is inadequate infrastructure, including unreliable internet, outdated devices, and incompatible hardware (Int. 4, Para. 62; Int. 15, Para. 42 Int. 17, Para. 74; Int. 33, Para. 51), pointed out by this statement:

> Without a doubt, the Wi-Fi is the biggest issue. It's honestly quite embarrassing — we provide students with iPads, yet there's no stable internet connection available. And even when Wi-Fi is technically

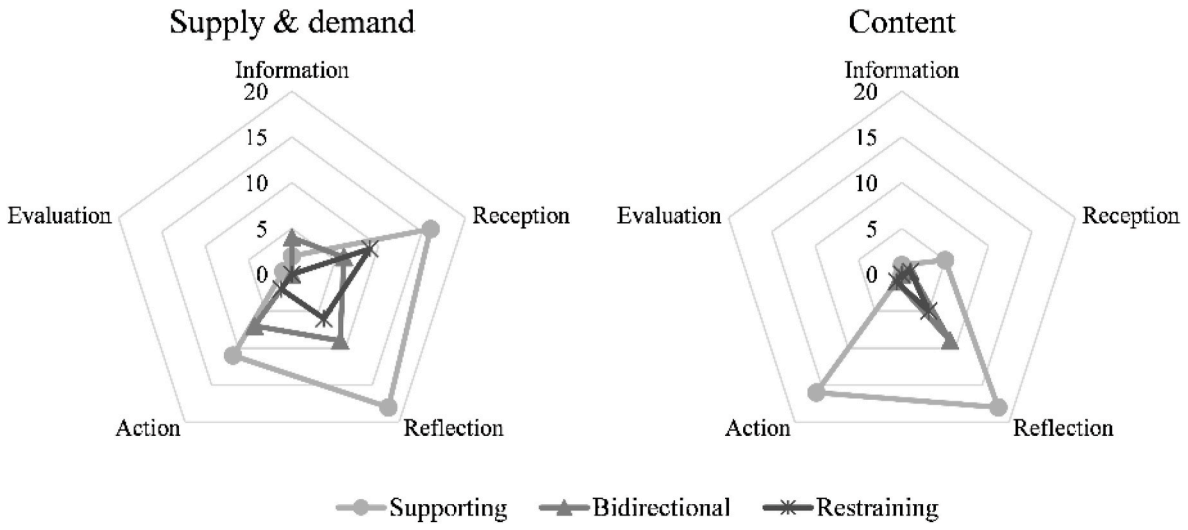


Fig. 6. Selected Sub-Categories of the Main Category 'Professional Development'
Note. Number of codings: Supply & demand of PD $n = 91$, content of PD programs $n = 58$. The number of codings for the ID phases can be found in Appendix C.

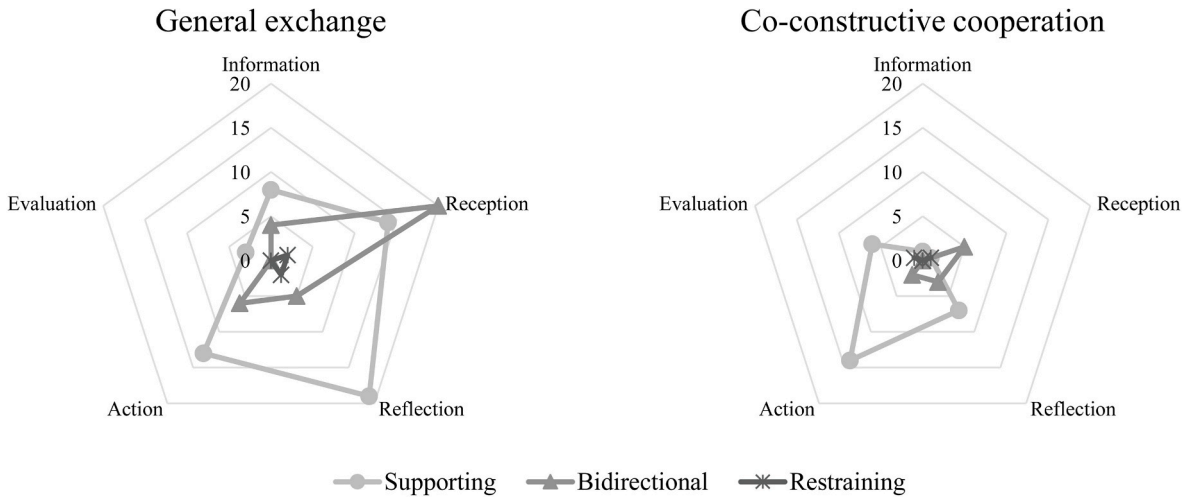


Fig. 7. Selected sub-categories of the main category 'cooperation'
Note. Nummer of codings: General exchange $n = 96$, Co-constructive cooperation $n = 41$. The number of codings for the ID phases can be found in Appendix C.

present, it works properly only about half the time. That's just the reality we're dealing with in 2023. (Int. 5, Para. 56)

Even when equipment is available, technical issues disrupt teaching, such as failing to connect to digital boards, preventing the display of student work (Int. 1, Para. 17). These obstacles hinder digital media use, evaluation, and ultimately, the success of digital ID. Teachers highlight the necessity of resilience in addressing such challenges (Int. 1, Para. 32). However, digital infrastructure has improved in recent years (Int. 20, Para. 80), and teachers recognize its role in facilitating successful ID processes (Int. 25, Para. 47; Int. 30, Para. 16). As highlighted in a statement made by one participant: "Even the usage – I mean, the amount of use of digital media – has increased significantly." (Int. 17, Para. 41)

4.2.5. Framework conditions

The **framework conditions** category encompasses the most sub-categories, reflecting diverse factors (Table 1). Teachers report that external stakeholders, such as vocational education companies and parents, have little influence on classroom ID processes, despite their vested interest in modern education (Int. 18, Para. 61; Int. 23, Para. 27; Int. 28, Para. 40; Int. 14, Para. 56). School administration plays a crucial role in supporting the "**action**" phase (Fig. 9), primarily by allocating resources and providing incentives, such as funding for digital tools or credit hours for ID engagement (Int. 23, Para. 25, 27). However, administrators rarely initiate innovation, relying instead on bottom-up initiatives. Students are also seen as a positive influence, particularly in the "**reflection**" and "**evaluation**" phases. Teachers recognize the need to adapt their instructions to contemporary student needs (Int. 13, Para. 32).

Student feedback is crucial for assessing new approaches, as their engagement is essential for both the effectiveness and success of the ID process. (Int. 31, Para. 21). Conversely, time constraints represent a significant barrier, frequently disrupting the ID process during the 'reception' and 'reflection' phases (Fig 9). Time constraints lead teachers to default to traditional methods rather than investing in new digital approaches, as one teacher points out: *"Teachers continue using old methods because they lack the time to learn and implement new ones"* (Int. 9, Para. 62).

4.2.6. Extrinsic incentives

The CF of extrinsic incentives seems to have comparatively little influence on the process of digital ID (Fig. 4). Since there are relatively

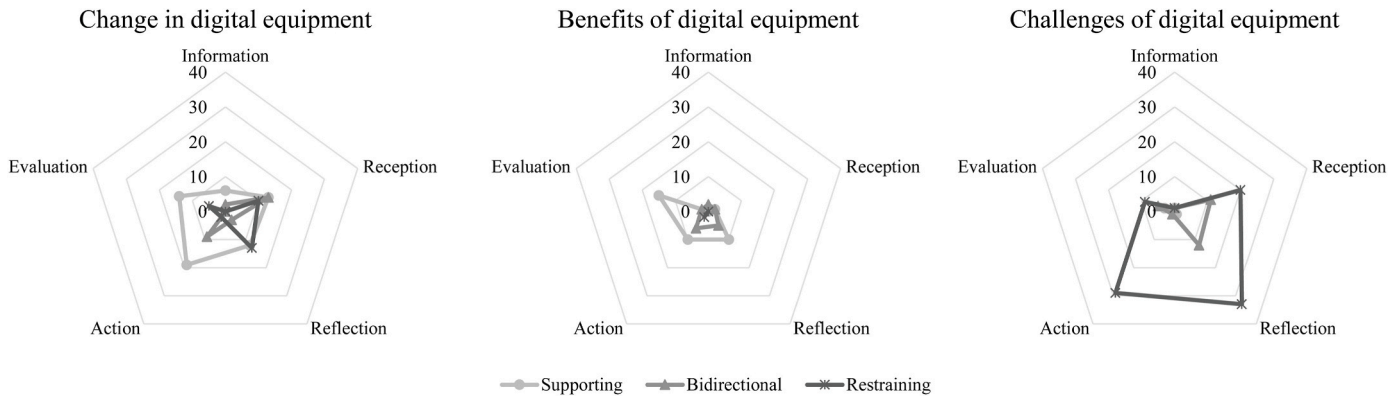


Fig. 8. Selected sub-categories of the main category 'digital equipment'
Note. Number of codings: Change in digital equipment $n = 122$, benefits of digital equipment $n = 56$, challenges of digital equipment $n = 127$. The number of codings for the ID phases can be found in Appendix C.

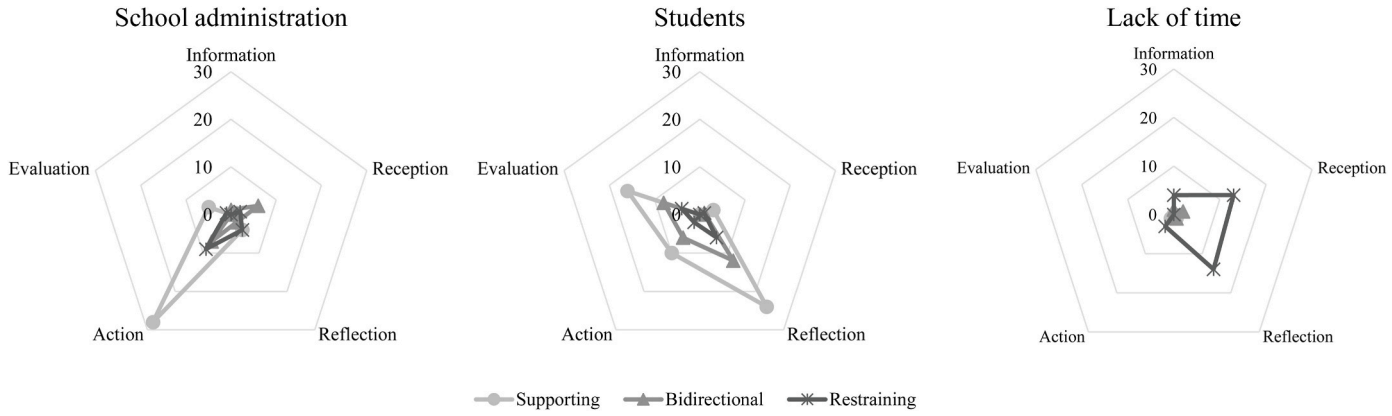


Fig. 9. Selected sub-categories of the main category 'framework conditions'
Note. Number of codings: School administration n = 70, Students $n = 93$, lack of time $n = 40$. The number of codings for the ID phases can be found in Appendix C.

few externally driven incentives, this isn't surprising. One example is the German teacher employment system, which is relatively rigid (Rackles, 2023) and offers few opportunities to reward dedicated teachers for their efforts (Int. 27, Para. 27). A closer examination of the dimensions of extrinsic incentives reveals that demand of time has an important impact. As highlighted previously, time constraints, appear to have a great restraining influence on the ID process (Int. 18, Para. 35). Although teachers are contemplating new digital instructional concepts, they are unable to implement them due to the absence of opportunities for time compensation (see Fig. 10). Teachers express the need for compensatory hours specifically for their digital ID (Int. 14, Para. 9). In the quotation below, readers can see how one participant elaborated on this point:

> If I had any compensatory hours or release time specifically for instructional development, it would certainly help. For example, if I were allocated time credits that allowed me to dedicate more time to

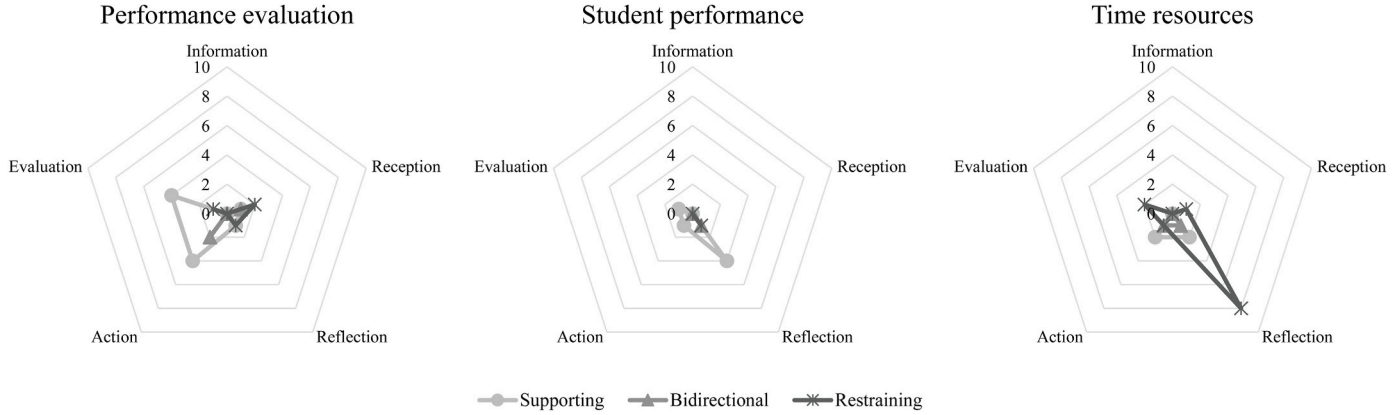


Fig. 10. *Sub-categories of the main category 'extrinsic incentives'*
Note. Number of codings: Performance evaluation $n = 17$, student performance $n = 8$, time resources $n = 19$. The number of codings for the ID phases can be found in Appendix C.

> instructional planning – these are, of course, extrinsic factors that can support such work. (Int. 4, Para. 36)

Beside of the time demands, some teachers see their students' success as an extrinsic incentive to get involved with digital ID (Int. 4, Para. 34) and others see an external incentive to engage them in digital ID in being evaluated by others (Int. 21, Para. 23).

4.3. Interconnection of CF

After the CF were initially considered separately and assigned to the ID process to demonstrate their influence in different phases of the process, this sub-section will address the strong interconnection of the CFs. The following example is intended to illustrate how teachers perceive this interconnection:

> It's not just the quality of the equipment; I would also emphasize the importance of ongoing training and professional development. Many textbook publishers offer excellent training courses. However, finding the time to attend these sessions can be challenging. If it's a one-day training course, it requires approval from the school administration, which adds another layer of difficulty. This often results in the cancellation of lessons, putting us in a dilemma. (Int. 31, Para. 70).

As illustrated by the previous example, when teachers encounter inhibiting CF, these often lead to compounded challenges, undermining the effectiveness of supportive measures. Even in the presence of high-quality digital equipment and well-designed professional development opportunities, a lack of sufficient time resources can prevent teachers from engaging in such training. This, in turn, results in a deficit of the necessary competencies to effectively integrate the available digital tools into their teaching practices (Int. 3, Para. 103).

In contrast, the interviews highlighted successful digital ID initiatives, where the success was not attributed to a single CF but rather to the interconnection of several factors. For example, the teachers expressed a positive attitude towards technological innovations and found the professional development opportunities provided to be highly valuable. Additionally, the teachers worked collaboratively on a unified digital ID project, with strong support from the school leadership, ensuring that the necessary resources for its successful implementation were available (Int. 1, Para. 23; Int. 2, Para. 22).

These examples, both positive and negative, are prevalent across nearly all interviews, highlighting the complex interconnection of CF in successful digital ID initiatives. While it is essential to examine individual CF in detail in order to identify specific improvements, it is equally important to recognize that a truly effective digital ID strategy cannot ignore the broader context of these interconnected CF. Thus, the following discussion will explore the concept of the school autonomy as a potential solution. Each institution must adapt its approach to meet its unique challenges, underlining the need for a tailored strategy in addressing these issues.

5. Discussion and implications

Our findings add to the literature on digital ID by providing a holistic, deepened view in the whole process of digital ID. In addition to providing a deeper understanding of the CF and their influence on the process of digital ID, it is possible to derive practical implications from this.

Our results underscore that the absence of targeted PD programs on the effective use of educational technologies can significantly hinder progress (Chaharbashloo et al., 2024; Talafian et al., 2025). When teachers are not provided with structured and context-sensitive training opportunities, they often lack the confidence and competence to integrate these tools meaningfully into their instructional practices. Moreover, technical issues with the devices themselves, such as inconsistent functionality or lack of support infrastructure, pose additional challenges that further complicate implementation (Liu & Zhang, 2024). These combined barriers place teachers in difficult positions, where expectations for digital or innovative instructional design clash with classroom realities. As a result, many educators face a dilemma between pedagogical aspiration and feasibility, leading in some cases to a narrowing, restricting, or even abandoning of the ID process (Compagnoni et al., 2024; Opstoel et al., 2025).

Nonetheless, our findings also reveal encouraging perspectives that can support the successful implementation of digital teaching innovations. A significant number of teachers exhibit strong intrinsic motivation to engage with and apply new digital methods in their classrooms (Int. 1, Pos. 9), which has been shown to be a key predictor of innovation adoption in educational contexts (Liu & Zhang, 2024). Intrinsic motivation, particularly when reinforced by teacher self-efficacy and professional engagement, contributes positively to the integration of digital tools in pedagogical practices. Moreover, the role of supportive school administration is crucial in this process. Recent studies emphasize that when school leadership actively provides time resources, sets clear expectations, and fosters a culture of experimentation and collaboration, teachers are more likely to embrace technological change (Schmitz et al., 2025). Administrative support thus serves as an important structural condition for innovation. In addition, access to high-quality technical infrastructure remains a foundational requirement. Schools equipped with reliable hardware, stable internet access, and platform diversity enable educators to explore digital teaching without being hindered by logistical constraints (Loh et al., 2025). This technical readiness is increasingly recognized as a determinant for sustainable digital transformation in schools. Lastly, a collaborative culture among teachers — facilitated through professional learning communities or informal peer networks — fosters the shared development and dissemination of teaching materials. As highlighted by Guggemos and Seufert (2021), such collaboration not only enhances the quality of resources but also contributes to teachers' professional growth and collective efficacy in implementing digital instruction.

A key insight emerging from our study is the necessity of understanding the interplay between different conditional factors that influence the success of digital instructional innovation. While individual components — such as teacher open-mindset towards digitalization, support from school administration, digital equipment, or collaboration — are each important in their own right, their impact is significantly amplified when considered in combination. For example, intrinsically motivated teachers may still face substantial barriers if their schools lack sufficient time resources or technical infrastructure. Conversely, even well-equipped schools may struggle to innovate if teachers are not professionally supported or intrinsically driven. Recent research underscores this interdependence: successful ID is rarely the result of isolated interventions but rather emerges from coherent ecosystems in which structural, cultural, and personal factors align (Keller & Thompson, 2024; Rivera et al., 2025). A holistic view, therefore, becomes essential — not only to identify existing gaps, but also to design interventions that are context-sensitive and mutually reinforcing. Integrated approaches allow for sustainable change by acknowledging the complexity of school environments and the need for tailored, systemic solutions. Such a perspective shifts the focus from discrete initiatives to comprehensive capacity building, in which innovation is embedded within the broader culture and structures of the school.

5.1. Practical implications

Our research insights have critical practical implications. Educational leaders and school developers must recognize the interconnectedness of CF to create supportive conditions for digital ID. Practical strategies might include the structured provision of professional development programs, dedicated timeslots within school schedules, and mechanisms for regular technical maintenance. Furthermore, given that

digital ID initiatives are frequently initiated by intrinsically motivated teachers, a structured support system is essential to prevent overwork and project termination due to insufficient resources or recognition. Effective school leadership must actively foster digital literacy and create environments that encourage innovation and collaboration among educators, thus significantly enhancing digital ID's success and sustainability (Wollscheid et al., 2024).

From a broader educational policy perspective, increased school autonomy has been positively linked with improved student performance and enhanced instructional innovation (Hanushek et al., 2013; Schleicher, 2018; OECD, 2016). Schools that can independently tailor their teaching methods are more likely to meet the diverse needs of their students, leading to more effective and engaging learning experiences. Moreover, school autonomy encourages innovation in teaching and management. PISA reports indicate that countries with higher levels of school autonomy tend to achieve better academic results (OECD, 2016). A study by the National Center on Education and the Economy (Schleicher, 2018) also found that high-performing countries often grant significant autonomy to schools, allowing for tailored and effective educational practices. Furthermore, greater school autonomy can enhance community involvement and accountability. Schools with the freedom to engage local stakeholders, including parents, businesses, and community organizations, can build stronger support networks and foster a sense of shared responsibility for educational success. This community engagement is essential for creating an educational environment that reflects local values and needs, increasing student motivation and support for schools.

It becomes evident that not only the ID process itself is relevant, but also, more broadly, progressive policy changes that recognize the importance of digital education and provide the necessary funding and resources can alleviate many of the restraining factors of digital ID. Although the fundamental structures of SD and ID are comparable to those in other countries, our results underline that the effective integration of digital innovations is not sufficiently implemented in the observed German school-types. Nonetheless, our findings are pertinent to innovative and digitally advanced schools, as continuous digital ID is crucial in adapting to ongoing digital transformations. Policies should consider on further developing the current framework of school autonomy in a targeted manner within which digital education can flourish (OECD, 2023).

6. Conclusion

By using Helmke's (2022) sequence model and the in-depth insights gained from the interviews, we are not only able to link the context factors with the ID process, but also show that the CF cannot be considered separately but must be viewed holistically and that their effect on the ID process plays a decisive role. Moreover, we are able to show that the CF have different effects in the phases of ID process. Through our qualitative and holistic approach, we can illustrate that an innovative digital ID process requires a lot of resources from a wide range of stakeholders. Given that the time resources of teachers are a crucial factor, it is essential to further develop and clearly define these resources to enhance ID. In addition, professional development programs should focus more on how teachers can recognize and overcome restraints in the early phases ('reception' and 'reflection' phase), so that less motivated teachers can engage more deeply with digital technologies and thus recognize the possible advantages and facilitations of the technologies.

The research on digital ID is of great importance since digital innovation and change is an ongoing topic. As new methods emerge, it is crucial to continuously update and improve digital identities to stay current and effective in an ever-evolving digital landscape. Therefore, measures had to be taken to support this transformation. We discussed the autonomy of schools as a promising approach, but other solutions should also be considered. With our research, we can build on existing studies on digital ID and deepen our understanding by incorporating a holistic view on CF. A limiting factor is that it was not possible to clearly identify group differences with our qualitative data. However, there were indications of differences within a few CF regarding school types. Therefore, further research is necessary to empirically examine the CF and their interactions more closely.

CRediT authorship contribution statement

Lisa Matuschek: Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Formal analysis, Data curation, Conceptualization. **Tobias Hackenberg:** Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Data statment

Data will be made available on request.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used ChatGPT 4.0 in order to improve the readability and language of the manuscript within the writing process. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors are grateful to Prof. Dr. Susanne Weber, Dr. Stefanie Zarnow and Dr. Frank Hiller for their comments and support for this article.

Glossary

Instructional Development ID
Professional Development PD
Conditional Factors CF

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tate.2025.105224.

Data availability

Data will be made available on request.

References

Almerich, G., Gargallo-Jaquotot, P., & Suárez-Rodríguez, J. (2024). ICT integration by teachers: A basic model of ICT use, pedagogical beliefs, and personal and contextual factors. *Teaching and Teacher Education, 145*, Article 104617. https://doi.org/10.1016/j.tate.2024.104617

Anthony, A. B., & Clark, L. M. (2011). Examining dilemmas of practice associated with the integration of technology into mathematics classrooms serving urban students. *Urban Education, 46*(6), 1300–1331. https://doi.org/10.1177/0042085911416015

Barak, M. (2024). Educational ideals and classroom realities: Developing teachers' concepts of dialogic pedagogy in real-world contexts. *Teaching and Teacher Education, 138*, Article 104401. https://doi.org/10.1016/j.tate.2023.104401

Bosch-Stiftung. (2023). Deutsches schulbarometer. *Befragung Lehrkräfte*. https://www.bosch-stiftung.de/de/projekt/deutsches-schulbarometer.
Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology, 3*(2), 77–101.
Bundesministerium für Bildung und Forschung. (2023). *Fortschrittsbericht DigitalPakt Schule 2022–2023 [progress report DigitalPakt Schule 2022–2023]*. https://www.bmbf.de/SharedDocs/Downloads/de/2023/230719-fortschrittsbericht-digitalpakt-schule.pdf.
Campbell, L. (2020). Teaching in an inspiring learning space: An investigation of the extent to which one school's innovative learning environment has impacted on teachers' pedagogy and practice. *Research Papers in Education, 35*(2), 185–204. https://doi.org/10.1080/02671522.2019.1568526
Caspari-Gnann, I., & Sevian, H. (2022). Teacher dilemmas as sources of change and development. *Teaching and Teacher Education, 112*, Article 103629. https://doi.org/10.1016/j.tate.2021.103629
Chaharbashloo, H., Gholami, K., Aliasgari, M., Talebzadeh, H., & Mousapour, N. (2020). Analytical reflection on teachers' practical knowledge: A case study of exemplary teachers in an educational reform context. *Teaching and Teacher Education, 87*, Article 102931. https://doi.org/10.1016/j.tate.2019.102931
Delcker, J., & Ifenthaler, D. (2021). Teachers' perspective on school development at German vocational schools during the COVID-19 pandemic. *Technology, Pedagogy and Education, 30*(1), 125–139. https://doi.org/10.1080/1475939X.2020.1857826
Dick, W., & Reiser, R. A. (1995). Instructional planning: A guide for teachers. http://ci.nii.ac.jp/ncid/BA26682442.
Dulo, A. A. (2022). In-service teachers' professional development and instructional quality in secondary schools in Gedeo Zone, Ethiopia. *Social Sciences & Humanities Open, 5*, Article 100252. https://doi.org/10.1016/j.ssaho.2022.100252
Dwivedi, Y. K., Hughes, L., Ismagilova, E., Aarts, G., Coombs, C., Crick, T., Duan, Y., Dwivedi, R., Edwards, J., Eirug, A., Galanos, V., Ilavarasan, P. V., Janssen, M., Jones, P., Kar, A. K., Kizgin, H., Kronemann, B., Lal, B., Lucini, B., … Williams, M. D. (2021). Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management, 57*, Article 101994. https://doi.org/10.1016/j.ijinfomgt.2019.08.002
Gräsel, C., Fußangel, K., & Pröbstel, C. (2006). Lehrkräfte zur Kooperation anregen - eine Aufgabe für Sisyphos? [Encouraging teachers to work together – a Sisyphean task?]. *Zeitschrift für Padagogik, 52*(2), 205–219. https://doi.org/10.25656/01:4453
Guggemos, J., & Seufert, S. (2021). Teaching with and teaching about technology–Evidence for professional development of in-service teachers. *Computers in Human Behavior, 115*, Article 106613. https://doi.org/10.1016/j.chb.2020.106613
Gustafson, K. L., Branch, R. M., & Alpert, S. A. (1998). Survey of instructional development models, third edition. *Performance Improvement Journal, 37*(5), 36–39. https://doi.org/10.1002/pfi.4140370509
Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers, 3*, 275–285. https://doi.org/10.1016/j.susoc.2022.05.004
Hallinger, P., & Kovačević, J. (2019). A bibliometric review of research on educational administration: Science mapping the literature, 1960 to 2018. *Review of Educational Research, 89*(3), 335–369. https://doi.org/10.3102/0034654319830380
Hanushek, E. A., Link, S., & Woessmann, L. (2013). Does school autonomy make sense everywhere? Panel estimates from PISA. *Journal of Development Economics, 104*, 212–232. https://doi.org/10.1016/j.jdeveco.2012.08.002
Hartmann, U., Richter, D., & Gräsel, C. (2021). Same same but different? Analysen zur Struktur kollegialer Kooperation unter Lehrkräften im Kontext von Schul- und Unterrichtsentwicklung [Same same but different? Analyses of the structure of collegial cooperation among teachers in the context of school and teaching development]. *Unterrichtswissenschaft, 49*(3), 325–344. https://doi.org/10.1007/s42010-020-00090-8
Helmke, A. (2022). *Unterrichtsqualität und Professionalisierung: Diagnostik von Lehr-Lern-Prozessen und evidenzbasierte Unterrichtsentwicklung* [Teaching quality and professionalization: Diagnostics of teaching-learning processes and evidence-based lesson development]. *Klett Kallmeyer*.
Hernández-Romero, L., & Sun, X. (2021). Supportive learning environments at elementary level in China. *Educational Research for Policy and Practice, 20*(3), 325–347. https://doi.org/10.1007/s10671-020-09286-2
Hopkins, D., Stringfield, S., Harris, A., Stoll, L., & Mackay, T. (2014). School and system improvement: A narrative state-of-the-art review. *School Effectiveness and School Improvement, 25*(2), 257–281. https://doi.org/10.1080/09243453.2014.885452
Huber, S. G., & Skedsmo, G. (2016). Teacher evaluation - accountability and improving teaching practices. *Educational Assessment, Evaluation and Accountability, 28*(2), 105–109. https://doi.org/10.1007/s11092-016-9241-1
Klippert, H. (2003). *Schule entwickeln – Unterricht neu gestalten: Plädoyer für ein konzentriertes Innovationsmanagement* [Developing schools – redesigning lessons: Plea for focused innovation management]. In T. Brüsemeister, & K.-D. Eubel (Eds.), *Zur Modernisierung der Schule – Leitideen, Konzepte, Akteure: Ein Überblick [Modernizing the school – Guiding principles, concepts, players: An overview]* (pp. 272–280). transcript.
Knight, S., Dickson-Deane, C., Heggart, K., Kitto, K., Çetindamar Kozanoğlu, D., Maher, D., Narayan, B., & Zarrabi, F. (2023). Generative AI in the Australian education system: An open data set of stakeholder recommendations and emerging analysis from a public inquiry. *Australasian Journal of Educational Technology, 39*(5), 101–124. https://doi.org/10.14742/ajet.8922
Krzychała, S. (2020). Teacher responses to new pedagogical practices: A praxeological model for the study of teacher-driven school development. *American Educational Research Journal, 57*(3), 979–1013. https://doi.org/10.1016/j.compedu.2024.105331
Kultusministerkonferenz. (2017). *Bildung in der digitalen Welt: Strategie der Kultusministerkonferenz [Education in the digital world: Strategy of the Standing Conference of the Ministers of Education and Cultural Affairs]*. KMK. https://www.kmk.org/fileadmin/Dateien/pdf/PresseUndAktuelles/2018/Digitalstrategie_2017_mit_Weiterbildung.pdf.
Kultusministerkonferenz. (2021). In *Lehren und Lernen in der digitalen Welt: Ergänzung zur Strategie der Kultusministerkonferenz „Bildung in der digitalen Welt" [Teaching and learning in the digital world: Supplement to the Standing Conference of the Ministers of Education and Cultural Affairs' strategy "Education in the digital world"]*. KMK. https://www.kmk.org/fileadmin/Dateien/veroeffentlichungen_beschluesse/2021/2021_12_09-Lehren-und-Lernen-Digi.pdf.
Landis, J. R., & Koch, G. G. (1977). An application of hierarchical Kappa-type statistics in the assessment of majority agreement among multiple observers. *Biometrics, 33*(2), 363–374. https://doi.org/10.2307/2529786
Langelaan, B. N., Gaikhorst, L., Smets, W., & Oostdam, R. J. (2024). Differentiating instruction: Understanding the key elements for successful teacher preparation and development. *Teaching and Teacher Education, 140*, Article 104464. https://doi.org/10.1016/j.tate.2023.104464
Leithwood, K., Sun, J., & McCullough, C. (2019). How school districts influence student achievement. *Journal of Educational Administration, 57*(5), 519–539. https://doi.org/10.1108/JEA-09-2018-0175
Lewalter, D., Kastorff, T., & Moser, S. (2023). *Digitalisierungsbezogene Lerngelegenheiten und -aktivitäten in Schule und Freizeit* [Digitalization-related learning opportunities and activities in school and leisure time]. In D. Lewalter, J. Diedrich, F. Goldhammer, O. Köller, & K. Reiss (Eds.), *PISA 2022: Analyse der Bildungsergebnisse in Deutschland [PISA 2022: Analysis of educational outcomes in Germany]* (pp. 237–272). Waxmann.
Lim, C. P., & Chai, C. S. (2008). Rethinking classroom-oriented instructional development models to mediate instructional planning in technology-enhanced learning environments. *Teaching and Teacher Education, 24*(8), 2002–2013. https://doi.org/10.1016/j.tate.2008.05.004
Liu, Y., & Zhang, X. (2024). Unboxing the black box: How Principal's regulatory focus shapes teacher innovative pedagogies. *Teaching and Teacher Education, 148*, Article 104692. https://doi.org/10.1016/j.tate.2024.104692
Loh, R. S. M., Kraaykamp, G., & van Hek, M. (2025). Plugging in at school: Do schools nurture digital skills and narrow digital skills inequality? *Computers & Education, 226*, Article 105195. https://doi.org/10.1016/j.compedu.2024.105195
Lui, A. M., & Bonner, S. M. (2016). Preservice and inservice teachers' knowledge, beliefs, and instructional planning in primary school mathematics. *Teaching and Teacher Education, 56*, 1–13. https://doi.org/10.1016/j.tate.2016.01.015
Maag Merki, K. (2020). *Schulentwicklungsforschung* [School development research]. In T. Hascher, T.-S. Idel, & W. Helsper (Eds.), *Handbuch Schulforschung [Handbook of school research]* (pp. 1–21). Springer.
Mayring, P. (2014). *Qualitative content analysis: Theoretical foundation, basic procedures and software solution*. Klagenfurt. https://nbn-resolving.org/urn:nbn:de:0168-ssoar-395173.
Mayring, P. (2021). *Qualitative content analysis: A step-by-step guide*. Sage.
Morrison, G. R., Ross, S. M., & Kemp, J. E. (2017). *Designing effective instruction*. SAGE Publications, Inc. eBooks. https://doi.org/10.4135/9781071801017.n4
OECD. (2016). *PISA 2015 results (Volume I): Excellence and equity in education*. OECD Publishing. https://doi.org/10.1787/9789264266490-en
OECD. (2023). Policies for the digital transformation of school education: Proposed analytical framework and methodology. *OECD Directorate for education and skills. EDU/EDPC/SR(2023)2* https://one.oecd.org/document/EDU/EDPC/SR(2023)2/en/pdf.
Orlando, J. (2014). Veteran teachers and technology: Change fatigue and knowledge insecurity influence practice. *Teachers and Teaching, 20*(4), 427–439. https://doi.org/10.1080/13540602.2014.881644
Rackles, M. (2023). *Lehrkräftearbeitszeit in Deutschland: Veränderungsdruck und Handlungsempfehlungen* [Teacher working hours in Germany: Pressure to change and recommendations for action]. *Deutsche Telekom Stiftung*.
Rolff, H.-G. (2023). *Schulentwicklung kompakt: Modelle, Instrumente, Perspektiven [school development compact: Models, instruments, perspectives]*. Beltz Pädagogik, 4th, completely updated and expanded.
Runge, I., Lazarides, R., Rubach, C., Richter, D., & Scheiter, K. (2023). Teacher-reported instructional quality in the context of technology-enhanced teaching: The role of teachers' digital competence-related beliefs in empowering learners. *Computers & Education, 198*(2023), Article 104761. https://doi.org/10.1016/j.compedu.2023.104761
Sailer, M., Murböck, J., & Fischer, F. (2021). Digital learning in schools: What does it take beyond digital technology? *Teaching and Teacher Education, 103*, Article 103346. https://doi.org/10.1016/j.tate.2021.103346
Schleicher, A. (2018). *World class: How to build a 21st-century school system (strong Performers and successful Reformers in education)*. OECD Publishing. https://doi.org/10.1787/9789264300002-en
Schmitz, M. L., Antonietti, C., Consoli, T., Gonon, P., Cattaneo, A., & Petko, D. (2025). Enhancing teacher collaboration for technology integration: The impact of transformational leadership. *Computers & Education, 226*, Article 105331.
Wollscheid, S., Tømte, C. E., Egeberg, G. C., Karlstrøm, H., & Fossum, L. W. (2024). Research trends on digital school leadership over time: Science mapping and content analysis. *Education and Information Technologies*. https://doi.org/10.1007/s10639-024-12909-3