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Jingle-Jangle in the Measurement of Digital Competences

An Attempt at Clarification Using (Prospective) Teachers as an Example

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Abstract
The rapid integration of digital processes into professional settings requires continuous training in digital media to promote the development of digital competence. To scientifically investigate and verify these continuing educational processes, the construct of digital competence must be operationalized. This poses challenges in the quantitative measurement of the construct and calls for open dialogue. This paper highlights the challenges faced in investigating and measuring digital competence using research on teachers as an illustrative example. Current challenges are (a) the absence of a unified definition of digital competence, (b) debates regarding the relation between basic and professional digital competence, (c) questions about the justification of skills, knowledge, and motivation, as well as (d) issues with inconsistent terminology and the mismatch with existing measurement, referred to as jingle-jangle fallacies. These challenges jeopardize transparency and interdisciplinary dialogue in the field. The paper discusses existing challenges and proposes solutions for enhancing transparency and avoiding research pitfalls. Strategies such as establishing accurate theoretical foundations, clarifying the elements of the competence being measured, and employing precise terminology are suggested to advance interdisciplinary research on teachers' digital competence.

Jingle-Jangle in der Messung digitaler Kompetenzen von (angehenden) Lehrkräften. Ein Aufklärungsversuch

Zusammenfassung
Die rasante Integration digitaler Prozesse im beruflichen Umfeld erfordert eine kontinuierliche Weiterbildung im Umgang mit digitalen Medien, die zur Entwicklung digitaler Kompetenz führt. Aus wissenschaftlicher Sicht ist die Operationalisierung des Konstrukts der digitalen Kompetenz notwendig, um solche Weiterbildungsprozesse zu untersuchen. Die quantitative Operationalisierung digitaler Kompetenz ist jedoch mit Herausforderun-

gen verbunden, die einen Dialog bedürfen. Dieser Beitrag beleuchtet die Herausforderungen, die sich bei der Untersuchung und Messung digitaler Kompetenz ergeben, wobei Forschung zu Lehrkräften als Beispiel der Erläuterung genutzt werden. Aktuelle Herausforderungen sind (a) das Fehlen einer einheitlichen Definition, Debatten über (b) das Verhältnis von grundlegender und professioneller digitaler Kompetenz, (c) die Begründung von Fähigkeiten, Wissen und Motivation sowie (d) Probleme mit uneinheitlicher Terminologie und Messung, was als jingle-jangle Irrtum bezeichnet wird. Diese Herausforderungen gefährden die Transparenz und den interdisziplinären Dialog. In diesem Beitrag werden daher die Herausforderungen erörtert und einige Lösungen zur Verbesserung der Transparenz und zur Vermeidung von Fallstricken in der Forschung vorgeschlagen. Es werden Strategien vorgeschlagen, wie die Schaffung präziser theoretischer Grundlagen, die Klärung der zu messenden Kompetenzelemente und die Verwendung einer präzisen Terminologie gelingen kann, um das interdisziplinäre Forschungsfeld zur digitalen Kompetenz von Lehrkräften voranzubringen.

1. Introduction

The increasing digital processes in professional settings necessitates lifelong training in digital media use to develop digital competence (Cascio and Montealegre 2016). To scientifically investigate and verify these continuing educational processes, the construct of digital competence must be operationalized. There, however, exist several challenges in existing quantitative measurements to assess digital competence. The scientific field of digital competence is interdisciplinary, leading to various theories, terms, and definitions (Spante et al., 2018). The limited cross-communication between disciplines, coupled with the field's interdisciplinarity, thus, leads to the diverse labeling and measurement of similar constructs in empirical research (Rubach and Lazarides 2023). The multitude of instruments and misunderstandings can be summarized under the assumption that scales with the same label represent the same construct (jingle) or that scales with different names represent different constructs (jangle), known as the jingle-jangle fallacy (Marsh et al. 2003). Key challenges of investigating digital competence, thus, lie in formulating a unified definition of digital competence and justifying skills, knowledge, and motivation as elements of the competence construct (Rubach and Lazarides 2023; Blömeke, Gustafsson, and Shavelson 2015; Spante et al. 2018; Tulodziecki 2011).

The present paper discusses how these issues undermine transparency and interdisciplinary dialogue on digital competence within the context of open science. Open science strives to enhance the accessibility and reproducibility of scientific findings (UNESCO 2021). Clear communication of theoretical frameworks and definitions is fundamental for research advancement (European Commission, Directorate-General for Research and Innovation, and Salmi 2015; Vicente-Saez and

Martinez-Fuentes 2018). Moreover, such clarity fosters collaboration and knowledge exchange within the scientific community to expand and refine theoretical approaches and propose new hypotheses (European Commission, Directorate-General for Research and Innovation, and Salmi 2015; Vicente-Saez and Martinez-Fuentes 2018). To encourage interdisciplinary discourse, this paper summarizes some of the main challenges in understanding digital competence, using research on teachers to illustrate existing challenges and offer clarifications and strategies to navigate beyond the jingle-jangle fallacy.

2. Competence: The Complexity of the Construct

Addressing how to define and operationalize digital competence begins with establishing a theoretical definition of competence itself (Kauffeld 2000). The following section sets out to define the construct of competence.

Competence is essential for effective interaction within various environments and management of complex tasks (Erpenbeck et al. 2017; White 1959). It can be conceptualized either as a behavioral disposition that energizes and directs behavior (Elliot and Dweck 2007; Erpenbeck and Heyse 1999) or as a process that unfolds between cognitive and non-cognitive dispositions, skills, and performance (Blömeke, Gustafsson, and Shavelson 2015). Numerous definitions of competence exist, many elaborating on structural aspects (Weinert 2001a). One definition states that "competencies are conceptualized as complex ability constructs that are context-specific […] and closely related to real life" (Koeppen et al. 2008, 61). White (1959), however, focuses on motivation as an essential part of competence. Other scholars have defined competence more broadly as combining trainable cognitive skills and abilities that are used to solve problems with motivational and social commitment to solve problems effectively in various situations. Weinert (2001b) characterizes competence as a construct that combines abilities, skills, and motivational beliefs that are needed to solve problems in various situations. Closely related definitions describe competence as a combination of knowledge, skills, attitudes, and values (OECD 2005; Rychen and Hersh Salganik 2001). The variety of definitions illustrates that competence is a theory-relative construct (Erpenbeck and Rosenstiel 2003) and highlights the need to clarify the underlying theoretical understanding and define components to operationalize the construct, as suggested by Kauffeld (2000).

Scholars have highlighted the multifaceted nature of competence, emphasizing its developmental nature and describing competence as personally, socially, and situationally determined and also criterion-oriented (Blömeke and Kaiser 2017; Koeppen et al. 2008). Competence is not a biological predisposition, nor is it stable in quality over time. Competence is dynamic (Steinberg 2007). As such, it has been described as a vertical continuum with different performance levels and qualities

(see Figure 1; Bach 2013; Bley and George 2017). Competence also develops in the direct and indirect interrelation between dispositions (knowledge, motivation, and attitudes) and situation-specific cognitive skills (perception, interpretation of and decision-making in the situation) that inform performance (observable behavior) – this sets competence in a horizontal continuum (see Figure 1; Blömeke and Kaiser 2017; Steinberg, 2007). Moreover, the person-dependent nature of competence assumes variation both within and between individuals. Competence is therefore defined as an individual characteristic (Blömeke and Kaiser 2017) and is determined by a person's needs, motives, and goals. In addition, competence is determined by the social context, highlighting its dependence on the environment and its requirements, opportunities, and incentives (Heckhausen and Heckhausen 2018). Finally, it is crucial to recognize that competence is not monolithic but manifests as a diverse array of specialized competences (Steinberg 2007). This emphasizes that competence is criterion-referenced and domain-specific (Spencer and Spencer 1993; Weinert 2001a).

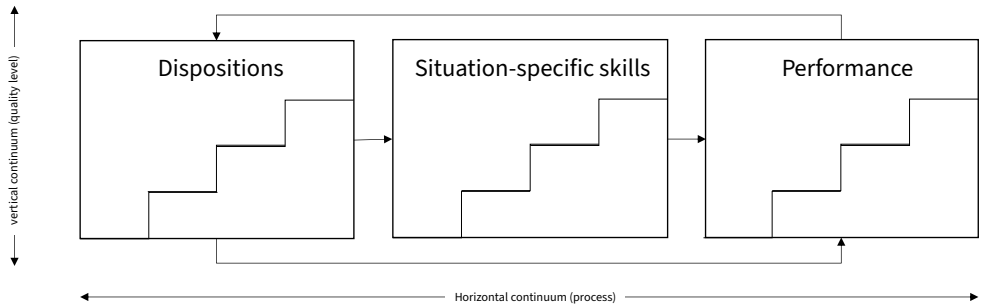

Fig. 1: Vertical and horizontal nature of competence (based on Blömeke and Kaiser 2017).

An unambiguous definition of competence is impossible due to the multitude of theoretical conceptualizations (Weinert 2001a). Most definitions of competence have a scientific justification. However, it is beneficial for scholars to clarify the theoretical foundation of competence to foster understanding of their concepts and promote interdisciplinary dialogue and collaboration on competence. For the purpose of the present paper, competence is understood as a synthesis of knowledge,[1]

1 Knowledge is defined as a cognitive representation of information that is received and stored by an information-processing system in which information can be retrieved and processed. Categories of knowledge are, for example, declarative, procedural, strategic, and metacognitive knowledge (Anderson and Krathwohl 2001).

(motivational) beliefs,[2] and skills[3] that manifest in performance (see Figure 1, Blömeke and Kaiser 2017). It has been argued that competence determines behavior (Erpenbeck and Heyse 1999). Therefore, the question of which components of competence determine behavior needs to be addressed. According to theory as well as empirical research, behavior is determined by how motivated individuals are, what particular kinds of knowledge they have, and what skills they are able to perform (Connell, Sheridan, and Gardner 2003). This is in alignment with the definition of multi-dimensional competence, which includes cognitive and affective-motivational characteristics (Blömeke and Kaiser 2017).

3. Competent Media Use: Comparing Media Competence and Digital Competence

The Council of the European Union (2018) identifies digital competence as one of the eight key competences for lifelong learning. Despite this, the EU report does not specify the details of what constitutes competent use of digital media. Exploring various concepts can shed light on this ambiguity. This section therefore elucidates the scope of digital competence by discussing the concepts of "media competence" (*Medienkompetenz*) and "digital competence" (*Digitale Kompetenz*), distinguishing these concepts from the related constructs of media literacy and digital literacy.

As is the case with the concept of competence, finding one definition and term for competence in using digital media is impossible (Spante et al. 2018; Zhao, Pinto Llorente, and Sánchez Gómez 2021). Internationally, there are different traditions of research on media use. While concepts of *media competence* and *media education* are established in Germany, *media literacy* is often used in the US context and *digital competence* is used in Europe more broadly (Grafe 2011; Spante et al. 2018). Media literacy, however, only focuses on the skill component of competence (see Fallon 2020) or on writing skills in the digital context (Zhang 2021). Thus, media competence or digital (media) competence are broader concepts describing what is required to master (digital) media. Although the concepts of media competence and media literacy should not be used synonymously, they have certain overlaps in structure and content (Fallon 2020; Thomann 2015; Tulodziecki 2011). In the following, we focus on media competence and digital competence to address the

2 Motivational beliefs are defined as beliefs integrated into mental processes that drive, select, and direct the intensity and persistence of behavior and thus answer the question "What do people want, and how do they go about getting it?" (Dweck, Dixon, and Gross 2023, 5; Locke 2023; Pekrun 2023). In this way, motivational beliefs motivate behavior: this process brings us closer to our desired state or averts us from a disliked state. Thus, motivation as a process aims to fulfill our physical and psychological needs (Dweck et al. 2023; Locke 2023).

3 Skills are defined as a "proficiency acquired through training and practice. […] Skills in other learned tasks include basic skills, communication skills, and social skills." (APA 2023).

requirements for mastering digital media. The aim here is not to deemphasize other concepts or reject them as irrelevant, but rather to highlight similarities and differences and direct attention toward teachers.

3.1 Media Competence and Digital Competence: Focusing on Similarities in Structure, Content, and Level

The competent use of media is considered desirable because it contributes to individual development in areas including education, social communication, and the job market (OECD 2021, OECD 2022; Thomann 2015). In German-speaking regions, two concepts are frequently juxtaposed when addressing the use of media: media competence and digital competence. Both are multi-dimensional, holistic concepts and contain various dimensions (McGarr and McDonagh 2019; Søby 2003), but media competence refers to the use of analog and digital media, making it more comprehensive than the concept of digital competence (Brandhofer et al. 2019). Digital competence can therefore be considered one component of media competence.

3.2 Media Competence

Media competence is described by Fromme (2009) as a process of actively exploring the current analog and digital media world and acquiring relevant behaviors. The definitions of the concept explicitly focus on declarative and procedural knowledge as well as associated skills (Thomann 2015). Baackes' idea of media competence focuses on communication with the help of analog and digital media, that is, print media, television, and computers, and focuses on understanding media and reality by using media and producing and designing media and reality (Baacke 1999). Four areas comprise media competence: knowing about media (*Medienkunde*), operating and using media (*Medien-Nutzung*), designing media (*Medien-Gestaltung*), and evaluating media (*Medien-Kritik*). Similarly to how Blömeke and Kaiser (2017) describe competences, media competence can be understood both as a prerequisite, an objective, or a process in dealing with media (Tulodziecki 2011).

3.3 Digital Competence

It is important to distinguish digital competence from the concept of media competence. Digital competence is not just a hollow phrase (Vollbrecht 2018) but delineates the knowledge, skills, and (motivational) beliefs individuals need to master digital media (Hämäläinen et al. 2021). Digital media are electronic data and formats represented and stored in a binary format using discrete numerical values (bits). They encompass various media types, including audio, video, images, text, and interactive

content that can be accessed, manipulated, transmitted, and shared through single digital devices. The structure of digital media relies on hardware components such as computers, smartphones, cameras, and storage devices. These devices are used for capturing, storing, reproducing, and displaying digital content. Additionally, software is utilized to create, edit, and distribute digital media.

As with competence and media competence, various scholars have provided definitions of digital competence. Spante et al. (2021) noted that most definitions of digital competence are politically underpinned. According to Calvani et al. (2008, 186), digital competence

> "consists in being able to explore and face new technological situations in a flexible way, to analyze, select and critically evaluate data and information, to exploit technological potentials in order to represent and solve problems and build shared and collaborative knowledge, while fostering awareness of one's own personal responsibilities and the respect of reciprocal rights/obligations."

Ferrari (2013, 3f.) refer to digital competence as a

> "set of knowledge, skills, attitudes (thus including abilities, strategies, values and awareness) that are required when using ICT and digital media to perform tasks; solve problems; communicate; manage information; collaborate; create and share content; and build knowledge effectively, efficiently, appropriately, critically, creatively, autonomously, flexibly, ethically, reflectively for work, leisure, participation, learning, socializing, consuming, and empowerment".

The definition by Ilomäki et al. focuses on skills and performance and describes digital competence as

> "consist[ing] of the skills and practices required to use new technologies in a meaningful way and as a tool for learning, working and leisure time, understanding the essential phenomena of digital technologies in society as well as in one's own life, and the motivation to participate in the digital world as an active and responsible actor" (Ilomäki et al. 2016, 670f.).

All definitions acknowledge the multifaceted nature of digital competence and list a variety of competence dimensions, such as problem solving or reflection on media use and the importance of skills and knowledge. Note that the definitions consider context: namely, work and leisure time (Ferrari 2013; Ilomäki et al. 2016).

4. Teachers' Digital Competence and the Focus on Basic and Professional Digital Competence

The conceptualization of digital competence varies across the domains of leisure and work, and individual digital competences can be examined from the perspective of both basic and profession-specific criteria (Falloon 2020; Krumsvik 2014). What implications do these variations have for our understanding of digital competence? We examine this question to explore the multifaceted nature of digital competence using research on teachers as an example for illustration. First, a definition of teachers' professional competence is needed. Afterward, the relation between teachers' basic and profession-specific digital competence is discussed. Lorenz and Endberg (2019) summarize that, on the one hand, basic digital competence is defined as integrated into the professional digital competence of teachers (hypothesis 1), while, on the other hand, basic digital competence is defined as a prerequisite for teachers' profession-specific digital competence (hypothesis 2, see Figure 2). Both hypotheses are based on somewhat different assumptions and are discussed from theoretical perspectives. One of these perspectives focuses on media (pedagogical media competences, Aufenanger 1999; Blömeke 2003) and the other on digital media (Huwer et al. 2019; Redecker 2017; UNESCO 2018). Furthermore, a third hypothesis defines digital competence as a socialization process combining basic and professional digital competence.

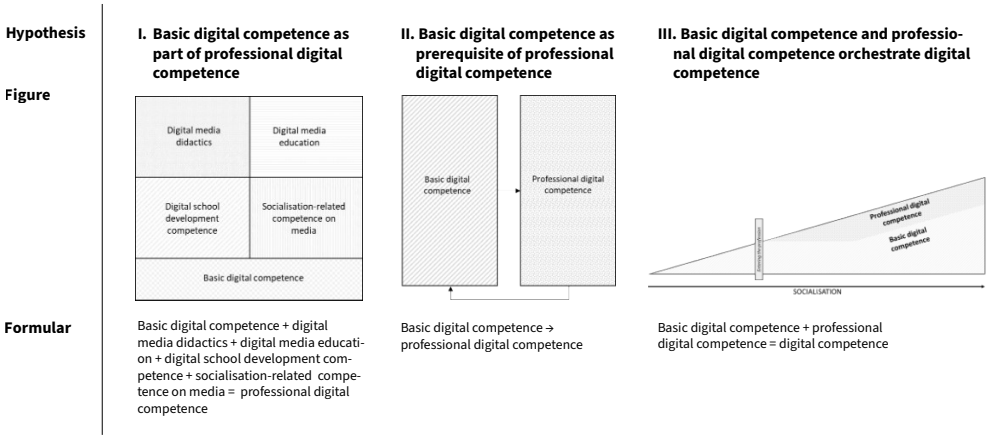

Fig. 2: Different approaches to define the relation between basic and professional digital competence.

4.1 Teachers' Professional Competence

Professional competences are needed to cope with and fulfill work-related demands (Bromme 2001; Weinert 2001a). Compared to the previously discussed global concept of competence, the same characteristics apply to professional competence but

are specialized in context and domain (Santagata and Yeh 2016). For the groups of teachers it is about mastering work-related requirements such as teaching, assessing, educating and innovating (Kultusministerkonferenz 2004). Models describing teachers' professional competence refer to the structure, criteria, level, and development of competence (Bach 2013). Blömeke and Kaiser (2017, 22) define

> "teacher competence […] as a multi-dimensional construct underlying performance in the classroom that includes knowledge, skills, and affective-motivational characteristics. Competence development and its transformation into performance were conceptualized as personally, situationally, and socially determined as well as embedded in a professional context."

In the generic COACTIVE model (Baumert and Kunter 2013), teachers' professional competence is defined as a nonhierarchical construct consisting of knowledge, beliefs/values/goals, motivational orientation, and self-regulated skills, which are further differentiated into facets.

4.2 The Relation Between Basic and Profession-Specific Criteria on Teachers' Digital Competence

4.2.1 Teachers' Pedagogical Media Competences – Basic Criteria as Integrated into Profession-Specific Criteria

The first hypothesis defines basic digital competence as integrated into teachers' professional digital competence (see Mishra and Koehler 2006; Blömeke 2000; UNESCO 2018). This assumption is guided, for example, by the overarching concept of media pedagogy (*Medienpädagogik*). Media pedagogy answers questions on the pedagogical significance of media and thus also digital media (Tulodziecki 2011). Tulodziecki (2012) has provided one concept of pedagogical media competences for teachers focusing on media education. Media education incorporates the skills of choosing, using, designing, evaluating, and reflecting on media for teaching and the consideration of media as a topic of teaching. Blömeke's (2003) concept of pedagogical media competences comprises five areas and is closely related to teachers' professional responsibilities: media didactics,[4] media education,[5] socialization,[6] school

4 The skill of reflecting on the use of media in appropriate forms of teaching and learning (see Blömeke 2000).

5 The skill of treating media as a teaching topic (see Blömeke 2000).

6 The skill of considering the learning prerequisites of students for the use of media as well as evaluate related learning progress (see Blömeke 2000).

development,[7] and media competence.[8] In this framework, media didactics, media education, socialization, school development, and media competence depend on one another, and media competence is described as a foundation. Both concepts highlight that all elements are relevant for the execution of professional tasks, with Tulodziecki considering teaching as a subject, and Blömeke also referring to non-teaching tasks such as school development. Thus, the first hypothesis has a reference point in the profession and aims to explain teachers' professional behavior. However, both concepts refer explicitly to teachers' skills even when referring to the concept of competence.

4.2.2 Teachers' Professional Digital Competence – Basic Criteria as Prerequisite of Profession-Specific Criteria

The second hypothesis defines basic digital competence as independent of but related to the profession (see European Commission et al. 2017). All citizens should have basic digital competence in order to participate in society (European Commission 2018). Here, the Commission makes reference to socialization processes in that basic digital competence starts to develop before individuals enter professional life. Basic digital competence is thus considered a prerequisite to deal with the wide variety of professional requirements and is comparable with competences such as reading and writing (European Commission 2018). However, this assumption does not mean that basic and professional digital competence cannot influence each other once a career has begun and professional competence has developed.

Many international theoretical and educational policy frameworks conceptualize teachers' professional digital competence with a specific focus on digital media (Krumsvik 2014; Mishra and Koehler 2006; Redecker 2017). One general model by Krumsvik (2014) separates teachers' digital competence into basic digital skills and professional pedagogical skills. The concept of professional (pedagogical) digital competences refers to digital media and is defined as "using ICT in a professional context with good pedagogic-didactic judgment and […] awareness of its implications for learning strategies and […] students" (Krumsvik 2011, 45f.). According to Krumsvik (2011), professional pedagogical skills can be differentiated into three areas: didactic ICT competence, learning strategies, and digital *Bildung*.[9] The author does not explicitly refer to the underlying concept of competence or relevant elements but does refer to knowledge and skills. Other models build on the knowledge dimensions of teachers described by Shulman (1998) (content knowledge,

7 The skill of innovative design of media use in school (see Blömeke 2000).

8 The skill of acting independently and appropriately with media in a creative and socially responsible way (see Blömeke 2000).

9 Didactic ICT competence refers to the use of digital media for subject-specific learning strategies, i.e. teaching and guiding students in the use of digital media; and digital *Bildung* refers to socio-cultural indices (see Krumsvik 2014).

pedagogical knowledge) and supplement them with technical knowledge (TPACK model, Mishra and Koehler 2006) or digital knowledge (DPACK model, Huwer et al. 2019). Both models define technical knowledge or digital knowledge as prerequisites for teachers to effectively integrate technologies into their classes and provide a systematization requiring that these knowledges be integrated with teachers' content knowledge and pedagogical knowledge. Here, knowledge is addressed as an element of teachers' professional use of technologies and digital media. Both Krumsvik's (2011; 2014) approach and the TPACK and DPACK models draw a distinction between basic and profession-specific criteria, either referring to knowledge (Mishra and Koehler 2006) or to knowledge and skills (Krumsvik 2014) as elements of the competence concept.

Other models are even more specific and describe teachers' basic and professional digital competence in detail. Rubach and Lazarides (2023) provide a model mapping basic and professional digital competence and related content areas (see Figure 3). They synthesize existing definitions of digital competence independent of professions (Law et al. 2018; Vuorikari et al. 2016) or focus on teachers and often cover only domains required for teachers and educators (Redecker 2017; UNESCO 2018). This research highlights six basic digital competence dimensions: (1) device and software operation, (2) information and data literacy, (3) communication and collaboration, (4) problem solving, (5) safety, and (6) content creation. Certain content is not covered by these dimensions, such as analyzing risks and benefits of business activities in digital environments (Rubach and Lazarides 2023). It has also been argued that the area of analyzing and reflection need to be included as further competence dimension (see Rubach and Lazarides 2021). The research also highlights six professional digital competence dimensions: (1) organization and administration, (2) professional engagement beyond the classroom, (3) teaching and learning, (4) empowering students, (5) assessment, and (6) facilitating students' ICT competence. Certain content is not covered by existing frameworks, such as classroom management using digital media. The competence areas that have not yet been covered might be a result of the progressive development of digital processes and newly identified facets (Rubach and Lazarides 2021, 2023).

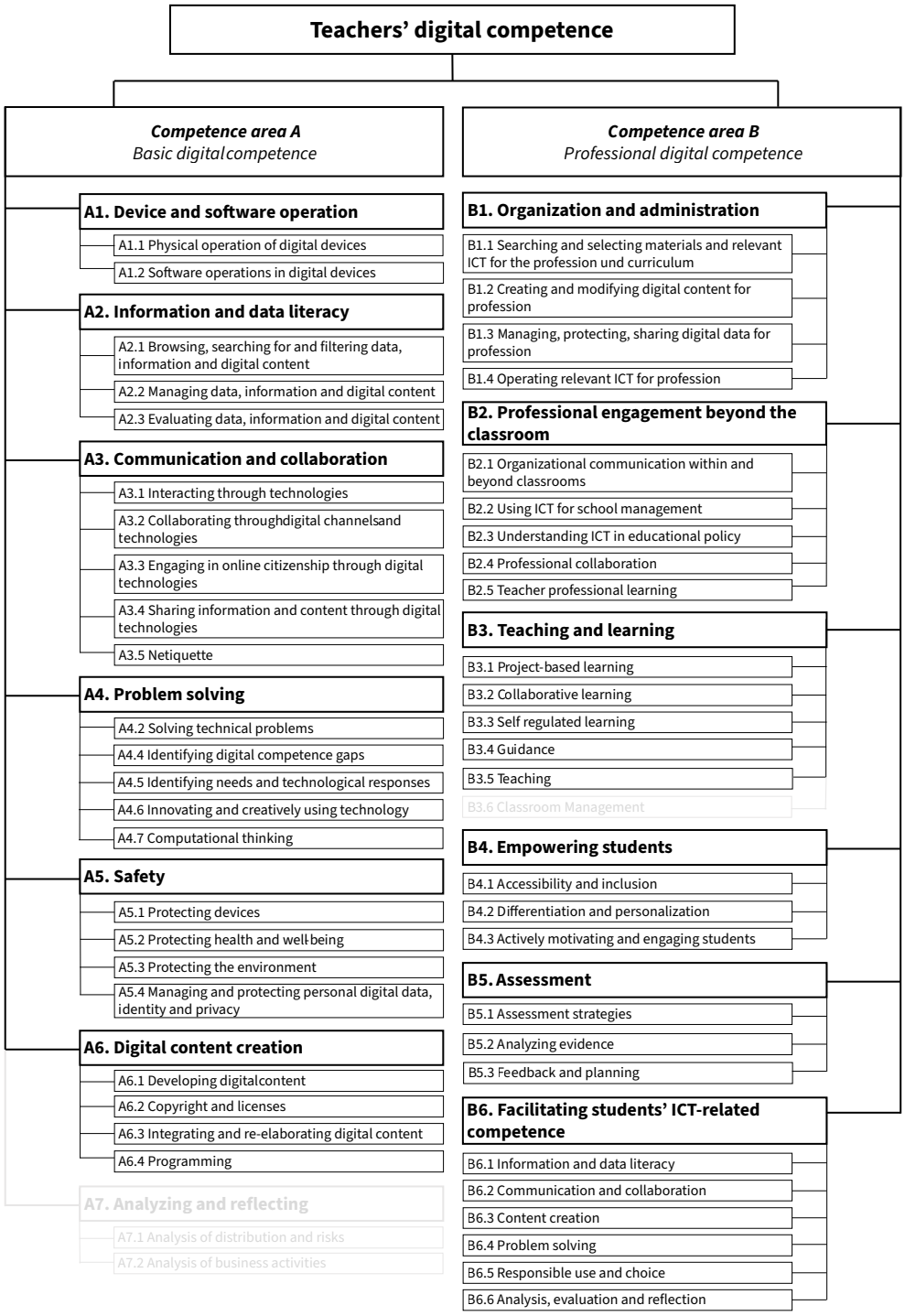

Fig. 3: Adapted overview on competence dimensions and sub-dimensions of teachers' digital competence (original from Rubach and Lazarides 2023, 196).

4.2.3 Teacher Digital Competences – Basic Criteria and Profession-Specific Criteria as Integrated Elements

A third hypothesis defines digital competence in reference to citizens and their socialization processes (Law et al. 2018). It assumes that basic digital competences and professional digital competences form the construct of digital competence (see Figure 3). This hypothesis supports a developmental perspective in assuming that basic digital competences develop in the course of socialization and are significant for each citizen whereas profession-related competences develop when a person takes up a profession. Here, competence using digital media is related to everyday life and the profession and is dependent on the person and the context (Blömeke, Gustafsson, and Shavelson 2015). Both competences are mutually dependent, whereby basic digital competence is taken as the starting point and foundation as described in hypotheses 1 and 2.

5. Current Challenges in the Field of Digital Competence

Numerous challenges lie ahead in the field of digital competence. In this section, we discuss challenges related to jingle-jangle fallacies and the mismatch between the definition of teachers' digital competence and existing measurement. Furthermore, the challenge of theoretically and empirically justifying knowledge, skills, and motivational beliefs as components of digital competence is discussed below.

5.1 The Issue of Jingle-Jangle in Frameworks, Terminology, and Measurement

Identical products with different brands and different products with similar brands, including counterfeits, pose challenges in economic settings: consumers who do not realize they are encountering the same product in a different guise or a cheaper alternative can become confused. A similar kind of confusion exists in psychological research. This section investigates the extent to which the phenomenon of jingle-jangle appears in the measurement of digital competences of teachers.

5.1.1 Jingle-Jangle Fallacy in the Concept of Teacher Digital Competence

A prerequisite for measuring competence is a competence model. When defining basic digital competences, studies refer to different frameworks. Research on teachers' digital competence is often guided by the EU framework model (European Commission 2006; 2018), findings by Ferrari (2012), or the DigComp model (Carretero et al. 2017; Vuorikari et al. 2016). A systematic review by Spante et al. (2018) notes that reference points for capturing digital competence of teachers are not limited to theoretical models but also refer to research results and policy frameworks. Spante et al. (2018) also report that 20 percent of the studied research on teachers' digital

competence does not define the construct. Others have commented that if researchers followed the path of providing information about the definition and models applied (Tulodziecki 2011), greater transparency could be achieved (Scharper 2009). This would counter the quite understandable claim that digital competence is a hollow phrase (Vollberg 2018).

The relevant question in this context is whether there are negative consequences for scientific knowledge gain when a variety of framework models are used to define the same construct. Do we need a unified definition of the construct of digital competence for teachers? The answer must be guided by the scientific goal. Digital competence is defined as a key competence that enables societal participation (European Commission, 2018). A goal should therefore be to gain knowledge about the extent of digital competences, the heterogeneity of their manifestation across groups, the ways digital competences develop, the factors that influence and hinder their development, and the actual impact of digital competence on societal participation. These goals apply to the professional group of teachers as well. When discussing negative consequences for scientific knowledge gain based on inconsistent concepts, these goals must be considered.

To the question about a unified definition of digital competence there are three possible responses: (1) Yes, we need one global definition of the construct of digital competence. This approach allows for valid instruments and the unambiguous comparability of different research findings. However, the use of one global definition carries the risk of losing disciplinary uniqueness and academic freedom and, according to Moser (2011), the risk of freezing a productive discourse or stagnation in engaging with the core construct. (2) Alternatively, one could argue that a universal definition is unnecessary. However, adopting this perspective carries the potential risk of research groups operating independently, resulting in limited validity and comparability of research outcomes. (3) A third answer could be that we do not need a unified definition and that we should instead define the constructs under investigation and aim to synthesize frameworks. Advantages of synthesizing are the illustration of the complexity of digital competences and the identification of content areas (e.g., Rubach and Lazarides 2023). To this end, however, it is imperative to establish transparency in understanding and ensure how definitions relate to each other. Strategies for implementation have been described in section 6.

5.1.2 Jingle-Jangle Fallacy in the Mismatch Between Terminology Used and Instruments

The use of various framework models results in the utilization of different terms, leading to the jingle-jangle problem. Internationally, the terms digital competence and digital literacy are commonly used to refer to the skill of effectively using digital technologies to navigate the digital landscape (Spante et al. 2018). The term digital competence is more prevalent in Europe, as noted by Spante et al. (2018). It focuses

on knowledge and motivation as elements of competence. In German-speaking regions, terms such as media literacy (*Medienkompetenz*), media education (*Medienbildung*), and digital competence (*digitale Kompetenz*) are used, as discussed by Thomann (2015). As noted above, media literacy and media competence, as well as digital literacy and digital competence, should not be used interchangeably as they represent different constructs.

Another challenge is ensuring that the various terminologies and definitions used in the field correspond accurately with the measurement instruments. Rubach and Lazarides (2023) point out a disconnect between the terminology used and the measurement instruments for the motivational element of digital competence: specifically, competence-related beliefs.[10] They compare various instruments that measure these beliefs in digital media use and identify several jingle-jangle fallacies: (1) the plethora of measurement tools available, and (2) the discrepancy in item usage, anchors, and dimensions even when measures share the same label. Furthermore, there is a confusion where (3) instruments are labeled as assessing "competence" or "knowledge" when in fact they measure motivational beliefs, and (4) instruments with different names use identical items (Rubach and Lazarides 2023). For example, many studies claim to measure competence but end up assessing only one of its components, often motivational beliefs (Rubach and Lazarides 2023). This highlights the challenge where terms used do not necessarily match the instruments employed, and the challenge we face with ill- or mislabeled instruments. The roots of this issue are multifaceted, possibly stemming from varied definitions of competence, lack of clarity in item use, translation issues, and the fuzzy lines between constructs (Madsen, Thorvaldsen, and Archard 2018).

Additionally, Rubach and Lazarides (2023) note inconsistencies in content across similarly labeled instruments. Most instruments evaluate self-perceived knowledge or skills in basic digital competences such as hardware and software operation and problem solving, and the domains of organization and administration and teaching and learning for professional digital competence in teachers (see Figure 3). Yet there is scant explanation for the choice of specialization or clarity on the dimensions each instrument aims to measure. For instance, two instruments labeled as "ICT self-efficacy" actually measure distinct competence areas and also dimensions: one focuses on hardware and software operation (Gudmundsdottir and Hatlevik 2018), while the other includes dimensions like professional collaboration and digital media teaching (Gnemu et al. 2020). The lack of a systematic approach in covering competence dimensions leads to an equality assumption among them, which

10 Competence-related beliefs include beliefs about own competence to solve a problem and/or master a task (Muenks et al. 2018). Included constructs are self-concept, expectancy for success, self-efficacy, and competence beliefs.

is a problematic stance in terms of content validity. Moreover, it may lead to the assumption that instruments measure the same constructs, especially when items are not provided.

With an awareness of such discrepancies, we must carefully consider the potential harm to the scientific community and our collective knowledge when measurements are not accurately named or defined. In this regard, three aspects could be considered: (a) limited validity and quality of research findings, (b) limited comparability of findings, and (c) a lack of interdisciplinary research.

5.2 Challenges Related to Knowledge, Skills, and Motivational Beliefs – All Indicators Have Their Justification

Studies on teachers' digital competence often state among their limitations that the measurement is based on self-reports (Zhao et al. 2021). Here, a concern is that teachers overrate their own knowledge and skills when self-reporting and that self-reports would thus be biased (Bjork, Dunlosky, and Kornell 2013). An implicit assumption of such a statement is that "practical test[s] of digital tasks may provide a better understanding of participants' digital competence" (Zhao et al. 2021, 11). The question is why such an approach gives a better understanding of digital competence and why overrating one's competence is problematic for the construct of competence. The difficulty with such statements is that motivational components of competence are denied their significance. In terms of content validity, the question is what needs to be measured and explained. If the goal is to capture knowledge in the sense of the TPACK model, for example, then self-reports of one's knowledge should be viewed critically. However, if the goal is to investigate the effects of self-efficacy on the design of instruction with digital media, then self-reports are appropriate. In the following section, we discuss the justification or necessity of the different elements of competences. We use three approaches: justification (1) from a methodological point of view, (2) from a content validity point of view, and (3) from a criterion validity point of view. In this context, the focus is on knowledge, skills, and motivational beliefs in line with the understanding of competence set out in this paper.

5.2.1 The Question of Justification From a Methodological Perspective

Hämäläinen et al. (2021) yielded significant findings for the field of digital competence among teachers: (a) skills in dealing with digital media have a weak correlation with attitudes towards using digital media, (b) attitudes toward the use of digital media do not correlate with knowledge of using digital media, and (c) only 12 percent of teachers who claimed to have necessary digital competences had their self-assessments confirmed by the knowledge test. One possible conclusion is that

the elements of competence are independent of each other. However, the findings presented and the measurement of the constructs used need to be interpreted with caution, as the operationalization in this study has weaknesses. It should be discussed in detail whether the items used to measure attitudes reflect behavior (e.g., "How often do you let students use ICT for projects or class work?") and the extent to which the items capturing knowledge reflect prior learning experiences (e.g., "Was the use of ICT for teaching included in your formal education or training?"). Such results could then imply a non-trivial implication that knowledge and attitudes towards digital media are independent of each other when, according to the item, it is actually behavior and past educational experiences that are being measured. This study is an example highlighting the ongoing challenge of operationalizing constructs in conjunction with ambiguously used terms. For instance, Rubach and Lazarides (2023), as described above, demonstrated that utilized items did not align with the terminology used: Some studies referred to competence or knowledge, even though they were actually measuring motivational beliefs, that is, competence-related beliefs. This points to the need to ensure a strong connection between construct definitions and items. Regarding the discussion on the justification of knowledge, motivational beliefs, and skills, little can be said from a methodological perspective about what element is more significant because empirical research still aims to investigate how an operationalization of the different elements of digital competence can be achieved.

5.2.2 The question of justification from the perspective of content validity

If the goal is to measure digital competence and make statements about the significance of competence for teacher behaviors, then competence should be measured in line with theory. According to Weinert (2001a) or Blömeke and Kaiser (2017), knowledge, skills, and motivational beliefs should be operationalized. From the perspective of research on motivation, which deals among other things with beliefs about skills, there may not be a theoretical necessity to measure knowledge or skills, but from the perspective of competence research, there is. Moreover, little is known about how knowledge, skills, and motivational beliefs compensate for each other. If only one construct was considered, no statements could be made about (a) whether all three elements predict behavior, (b) whether competence as a whole is significant, or (c) whether elements compensate for each other. Blömeke, Gustafson, and Shavelson (2015, 9) identify a research gap, stating that we do not know "whether the different dimensions of competence can compensate for each other (i.e., are additive by nature) or if strength on one cannot compensate for weakness on another dimension (i.e., multiplicative nature of competence dimensions)." This research gap is fundamental because there is little evidence regarding the extent to which teachers need to be trained in all competence elements and content areas

or whether high motivational beliefs compensate for low skills in, for example, effective use of digital media in teaching. Due to the limited research base and a conceptual understanding of the competence concept, all elements would therefore deserve investigation in the future.

5.2.3 The Question of Justification From the Perspective of Criterion Validity

When measuring and operationalizing a variable, the question of relevance for explaining a dependent variable arises. In the field of competence research, "real-world behavior [...] is the core validity criterion" (Blömeke, Gustafsson, and Shavelson 2015, 8). When it comes to psychological modeling of competence, the objective is to understand and recreate this effective navigation in various scenarios (Klieme, Hartig, and Rauch 2008). When examining teachers' digital competences, examples of dependent variables could be (a) the didactically effective use of digital media in teaching, (b) the use of digital media as a tool, or (c) teaching about digital media (Getto, Hintze, and Kerres 2018; Guggemos and Seufert 2021; Scheiter 2021). However, as Scheiter (2021) points out, these research fields are young, with little knowledge about what effective use of digital media in teaching means and what our dependent variable is in terms of criterion validity.

To justify the need for a comprehensive understanding of digital competence to explain teacher behavior with digital media, findings can be cited that do not have an explicit focus on digital media but aim to predict teacher behavior. Studies in the field of mathematics education, for example, show that subject-specific and pedagogical knowledge predicts teacher instructional quality as well as student performance (Baumert et al. 2010; Blömeke et al. 2022; Charalambous, Hill, and Mitchell 2012). Teachers' motivational beliefs, such as goal orientation, self-efficacy, or value beliefs, are linked to instructional quality as well as student motivation and performance (Holzberger, Philipp, and Kunter 2013; Künsting, Neuber, and Lipowsky 2016; Lazarides et al. 2021). Teacher skills are one of the factors that influence student performance (Blömeke et al. 2022). Depending on the variable to be explained, all elements of competence would have their relevance.

There are also findings from research on the elements of digital competence in teachers that demonstrate the explanatory power of knowledge, skills, and motivational beliefs in dealing with digital media. Studies show, for example, that motivational beliefs, specifically self-perceptions of skills and knowledge in using media, correlate with teaching behavior (Guggemos and Seufert 2021; Lohr et al. 2021; Quast, Rubach and Lazarides 2021) or even determine teaching behavior (Backfisch et al. 2020). However, note that the possibilities for measuring other elements than motivational beliefs as an element of digital competence are still pending, so making comparisons between the elements at this point would be counterproductive.

Thus, from the perspective of criterion validity, it cannot be confirmed that one element is more significant than another in explaining the dependent variables. This is also due to the rather broad understanding of the dependent variables.

In summary, the fifth section has shed light on a prevalent issue in digital competence research: the mismatch between the labels and the content measured by existing instruments. It has discussed the importance of instruments being precisely named to correspond with the particular aspects of competence they measure, be it knowledge, motivational beliefs, or skills. Given the diversity of terms like "competence" and "knowledge," precise definitions and meticulous item selection are critical to avoid confusion and move research forward. Furthermore, there is no empirical justification for ignoring particular elements of digital competence; instead, it is crucial to understand the importance of all elements and their interrelations. The subsequent section outlines strategies to enhance the alignment between our measurement instruments, the constructs they intend to measure, and the terms being used.

6. Strategies to Overcome Current Challenges of Jingle-Jangle Fallacies

Transparency and reproducibility, aligned with the principles of open science, are crucial for addressing the challenges described above. The question is how to provide an interdisciplinary, effective, and collaborative environment to investigate teacher digital competence? The following strategies, illustrated as a decision process in Figure 4, can help create transparency and are guided by previous work of Moser, Grell, and Niesyto (2011), RatSWD (2014), and Tulodziecki (2011):

a. Use precise theoretical foundations and definitions of the construct of competence. To implement open science in the best possible way, it is not necessary to pit different perspectives against one another. The goal is rather to classify them in the sense of scientific practice and to identify their respective specifics.
b. Clarify which elements of digital competence are being measured, such as knowledge, skills, or motivational beliefs. This allows for targeted assessment and analysis of relevant constructs. Also, check whether the items fit the definition of the construct, for instance, whether "I can ..." refers to knowledge or to motivational beliefs, that is, to competence-related beliefs.
c. Determine the reference point of the study, whether it is about ICT (information and communication technology), digital media, or media in general.
d. Indicate which competence area (basic or professional digital competence) and which competence dimension (criteria) is being investigated (see Figure 3). Highlight the underlying idea of the relationship between basic and professional digital competence and focus the hypotheses on how the instruments used are related to the dependent variable.

e. Use precise terminology that fits the investigated construct, even if it requires longer terms. One example would be to refer to teachers' perceived ICT knowledge rather than teachers' ICT knowledge when assessing competence-related beliefs (item anchor: "I can…"). This clearer and more theoretically grounded labeling can help avoid misunderstandings and ensure clearer communication.
f. Always provide used items for transparency and open science dialogue. Rubach and Lazarides (2023) classified reviewed items on basic and professional ICT competence-related beliefs. This overview might help other scholars to navigate the field.

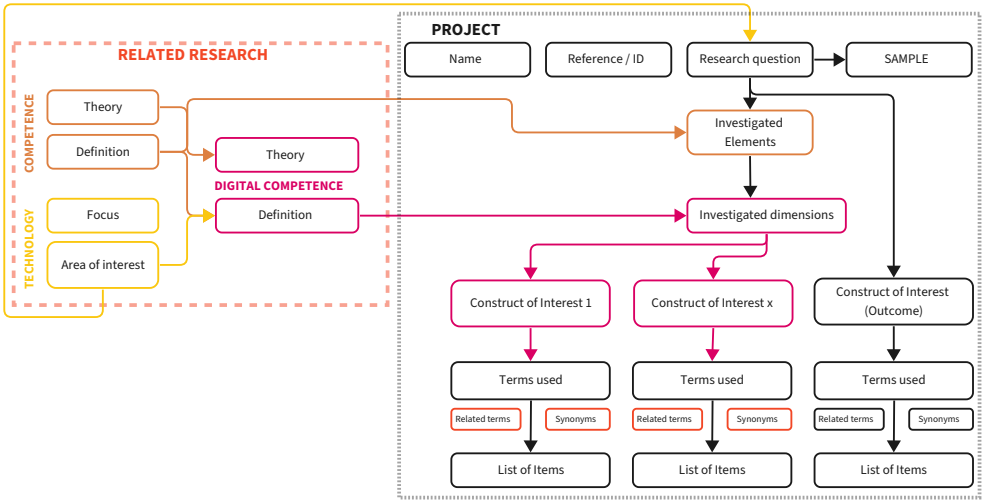

Fig. 4: Flowchart to write the uniform text template.

For the publication of study results, for example, a uniform text template could be used that makes it possible to provide all relevant information across studies:

> "This empirical study used a sample from *[name of the project, pre-registration ID]* and aims to investigate [*add investigated sample*] competence using [add focus, e.g., Information and Communication Technology (ICT), digital media, and media in general], i.e., [add area of interest]. Guided by *[theoretical understanding of competence]*, we define competence as *[add definition]*. Digital competence is defined as *[insert your specific definition of digital competence, and refer to incorporating elements such as knowledge, skills, motivational beliefs] [add references of definition]*. We narrow our focus to [*basic or professional digital competence*], i.e., [*motivational beliefs, skills, knowledge*]. As we aim to investigate [*add detailed context*], we focus on the competence dimensions [*list the competence dimensions*]. Thus, for our construct of interest, we use the terms *[add used terms of the construct]* in line with [*other authors*] which (a) captures our theoretical understanding of digital competence and

(b) improve the comparability of our findings to other scholars. We acknowledge that synonyms are used interchangeably in the literature to describe digital competence more precisely [*basic or professional digital competence + element of competence*], namely *[add term, and references].* The following [*number*] items (reference) are used to estimate *[add used term] [list the competence dimensions + items].* [*Add-on for dependent variable see below*]."

If authors investigate the link between some elements of teacher digital competence and outcomes such as teaching behavior, it is also reasonable to describe the dependent variable and explain why particular competence dimensions are covered in the instruments. An example is: "We also aim to investigate the relation between *[construct investigated] and [outcome]*." A roadmap for completing the template is illustrated in Figure 4.

7. Conclusion

Navigating the interdisciplinary research on digital competence is critical to the field's advancement but presents some challenges. These include inconsistencies in definitions, labeling, and measurement approaches, leading to a troubling proliferation of jingle-jangle fallacies. Constructs are often ill-defined, and instruments misaligned with theoretical definitions, compromising the validity of the construct (Rubach and Lazarides 2023; Spante et al. 2018).

The measurement of digital competence often centers on motivational beliefs due to a scarcity of instruments that assess knowledge and skills. A challenge emerges when the instruments assessing motivational beliefs are inaccurately represented as the entirety of digital competence. This approach not only misrepresents the construct but also compromises the validity of the measurement. Due to such ill-labeled instruments, scholars downplay the significance of motivational beliefs, for example, competence-related beliefs using digital media. The critique of a misalignment between instrument and label is valid; although motivational variables do not comprehensively represent digital competence, they are essential for understanding why people use digital media in certain ways (Backfisch et al. 2020; Quast et al. 2021). Also, the myriad of definitions and frameworks encountered in this field underscores the complexity of conceptualizing and operationalizing digital competences. A related challenge is that competence dimensions are covered unsystematically in existing instruments as they relate to various frameworks. It is necessary to understand the possible negative impact on the diversity of competence dimensions. Recognizing the multifaceted nature of digital competence is crucial, as there remains a considerable gap in our understanding of the interplay between knowledge, motivational beliefs, skills, or their collective influence on

digital media proficiency. It is within this context of complexity that we propose a solution to reduce jingle-jangle fallacies. We suggest the use of unequivocal terms that align with the theoretical frameworks on (digital) competence and are coherently matched with the operationalization used. To aid in this endeavor, we have developed a template designed to help researchers present all relevant information in their studies, ensuring a comprehensive representation of digital competence.

In conclusion, to surmount these challenges and foster an international dialogue free from confusion, researchers must strive for clarity in defining constructs, ensuring that labels fit the instruments used, and referencing each other's definitions in the spirit of open science – providing as much information as possible, including clear labels and item details. This transparency will not only disentangle the jingle-jangle fallacies but also encourage collaboration that transcends disciplinary boundaries. The evolution of digital competence research relies on our collective commitment to refine our understanding, measurement, and communication of this multifaceted construct, leading to a more coherent and unified field of study with potential benefits for society and education.

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