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A Proposed Instrument for Mapping Teacher Digital Competence: Design and Conceptual Framework

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Abstract

The digital transformation in education has created an urgent need for reliable instruments to map Teacher Digital Competence (TDC), particularly for in-service K–12 teachers. This urgency is heightened by the demands of 21st-century pedagogy, which emphasizes technological proficiency to support effective, inclusive, and sustainable learning. This study aims to develop the conceptual design and initial structure of a comprehensive, multidimensional TDC mapping instrument. The proposed instrument suite consists of two main components: a quantitative survey and a qualitative semi-structured interview protocol, both constructed around five core dimensions of TDC: Digital Pedagogy and Learning Design, Digital Resource Management and Creation, Digital Assessment and Feedback, Professional Engagement and Collaboration in Digital Environments, and Ethical and Responsible Digital Citizenship in Education. The instrument development employed an extensive literature review approach, synthesizing insights from leading theoretical models, including DigCompEdu, INTEF, COMDID, and other contemporary research. The primary outcome of this research is a systematically structured TDC mapping instrument equipped with measurable and context-relevant indicators. It is designed to support a mixed-method research approach, enabling the collection of both quantitative and qualitative data for deeper analysis. Although the instrument is currently at the conceptual stage, it holds significant potential for application in TDC mapping studies, evaluations of professional development programs, and the formulation of data-driven educational policies. Further empirical validation is recommended prior to broader implementation.

Keywords: *Teacher Digital Competence, Educational Technology, Instrument Design*

Introduction

The 21st century has ushered in an era of profound technological advancement, fundamentally reshaping societal structures and, with particular significance, the landscape of education. This digital transformation necessitates a new suite of capabilities from educators who are increasingly expected to integrate these technologies effectively into their teaching and learning processes (Butar et al., 2024). However, a significant empirical and theoretical problem persists: while the imperative for Teacher Digital Competence (TDC) is widely acknowledged, particularly accelerated by events like the COVID-19 pandemic, there is an ongoing challenge in comprehensively defining, measuring, and fostering this multifaceted competence (Esteve-Mon et al., 2022). This gap hinders the ability of educational systems to adequately prepare teachers, identify specific training needs and ensure that technology's potential to enhance pedagogical practices and student outcomes is fully realized (De los Ángeles Domínguez-González et al., 2025). The core issue lies in the need for robust,

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theoretically grounded, and contextually relevant instruments that can effectively map the diverse dimensions of TDC beyond mere technical skills (Basilotta-Gómez-Pablos et al., 2022).

Recent studies have extensively explored TDC, establishing a rich state-of-the-art. Numerous international and national bodies have proposed frameworks such as DigCompEdu, ISTE Standards, UNESCO ICT CFT, TPACK, INTEF, and COMDID to define TDC's key components (Lázaro Cantabrana et al., 2019). These frameworks generally cover areas like professional engagement, digital resources, teaching and learning, and assessment (Revuelta-Domínguez et al., 2022; Pinto-Santos, 2022). Conceptualizations of TDC have evolved from narrow 'digital literacy' to more holistic constructs like 'Teachers' Professional Digital Competence' (TPDC), emphasizing critical understanding, pedagogical integration, and ethical considerations (Falloon, 2020). Consequently, various assessment approaches have emerged, including self-assessment questionnaires and analyses of competence levels within specific populations (Gómez-Trigueros et al., 2021). However, a limitation of many existing instruments is that they may not always capture the full spectrum of TDC, particularly the more nuanced pedagogical applications, ethical digital practices, or the deeper implications for knowledge construction highlighted (Aydin & Yildirim, 2022). Furthermore, as systematic reviews often indicate, there is a continuous demand for assessment tools that are not only psychometrically sound but also adaptable for detailed mapping studies across various contexts and capable of informing targeted professional development (Skantz-Åberg et al., 2022).

The identified gap, therefore, lies in the need for a comprehensive instrument suite that not only draws from established frameworks like INTEF or COMDID but also explicitly incorporates the broader, more holistic conceptualizations of TDC, such as those proposed by and addresses often underrepresented yet critical areas (Peters et al., 2022). While many existing tools provide valuable quantitative data, often through self-assessment, there is a lesser emphasis on mixed-method approaches that can capture the rich, contextual qualitative data necessary for a deeper understanding of teachers' digital competence in practice (Nagel, 2021). This paper extends previous work by proposing an instrument specifically designed for detailed, multi-method mapping studies, aiming to provide a more nuanced understanding of teachers' digital capabilities. It seeks to build on, rather than challenge, the findings of previous instruments by offering a more granulated and qualitatively enriched perspective, particularly regarding the pedagogical integration and ethical dimensions of TDC.

This paper aims to address the identified gap by introducing the design and conceptual framework of a new, comprehensive suite of instruments, comprising a survey and an interview protocol, specifically intended for the nuanced mapping of Teacher Digital Competence in K-12 in-service teachers. The research objective is to present a detailed blueprint of this instrument suite, outlining its conceptual underpinnings derived from a synthesis of existing theoretical frameworks. its proposed dimensional structure, item types for the survey, and inquiry areas for the interview protocol. The novelty of this research lies in the integrated, mixed-method design of the suite and its specific focus on providing a comprehensive mapping tool that covers five core dimensions, including a strong emphasis on pedagogical integration and ethical digital practices, with the explicit understanding that subsequent empirical validation will be essential before widespread application.

Method

The development of instruments in this study was based on a systematic, literature-driven design approach. The process began with the identification of a pressing need for assessment tools capable of capturing the complex and diverse nature of Teacher Digital Competence (TDC) in a more nuanced and contextualized manner. A critical review of existing literature revealed that many previous instruments did not sufficiently reflect the pedagogical and ethical dimensions that are increasingly central to contemporary digital education practices. In response, a set of complementary instruments was designed, comprising a quantitative survey and a qualitative interview protocol to provide a comprehensive and multifaceted representation of the digital competence of in-service K-12 teachers.

The first step in the design process was the development of a conceptual framework to serve as the foundation for the instruments. This framework was constructed through an extensive synthesis of relevant literature, drawing upon a variety of international models and standards. The outcome of this synthesis was the identification of five core dimensions of TDC: (1) professional engagement in digital contexts, (2) use of digital resources, (3) integration of technology in teaching and learning, (4) digital-based assessment, and (5) ethical considerations and critical reflection in technology use. Each dimension was further elaborated into measurable sub-dimensions, with carefully formulated operational definitions to guide item development and the formulation of relevant inquiry areas.

Based on the conceptual framework, a survey instrument was developed to quantitatively map teachers' self-perceptions regarding their competence, practices, and attitudes toward digital technology use in educational settings. The item development strategy involved deriving specific indicators from each TDC sub-dimension. The instrument employed Likert scales to measure perceived levels of competence and frequency scales to capture the intensity of technology use. This format was informed by established practices in TDC assessment and tailored to the context of in-service teachers in primary and secondary education.

The complement the survey, a semi-structured interview protocol was also developed to explore teachers' subjective experiences in greater depth. The primary focus of the interviews was to investigate pedagogical reasoning, technology integration strategies, and challenges encountered in the development of digital competence. The interview questions were designed as open-ended prompts aligned with the five TDC dimensions, to elicit rich and meaningful narrative data. This approach is consistent with common practices in qualitative educational research, which emphasize contextual and interpretive understanding of the phenomena under investigation.

This article presents the initial phase of the instruments' conceptual and technical design. The next stage will focus on comprehensive empirical validation. This process will involve three key steps: (1) expert review to assess content validity by specialists in educational technology and assessment, (2) pilot testing with a representative sample of in-service teachers to evaluate item clarity, relevance, and reliability, and (3) in-depth psychometric analysis of the survey instrument, including reliability testing and construct validity assessment using appropriate statistical techniques (e.g., exploratory and confirmatory factor analyses). These steps are essential prerequisites before the instruments can be deployed in broader mapping studies or data-informed professional development interventions for teachers.

Results

The Teacher Digital Competence Dimensions

The proposed instrument suite for mapping Teacher Digital Competence (TDC) is structured around five core conceptual dimensions. These dimensions were meticulously derived from the comprehensive conceptual framework detailed in the Method section of this paper. The development of this framework was a synthetic process, informed by an extensive review of contemporary literature and prominent existing models. Specifically, it drew inspiration from the holistic perspective advocated in Teacher Digital Competency (TDC) framework and the recurring conceptual aspects of teachers' professional digital competence identified in the literature overview (Gisbert Cervera & Caena, 2022). Furthermore, the delineation of these dimensions was significantly guided by established and widely recognized European frameworks, notably the European Framework for the Digital Competence of Educators (DigCompEdu, as operationalized and discussed through various research, and Spain's Common Framework of Digital Competence for Teachers (INTEF, which forms the basis of instruments such as that validated (Peters et al., 2022; Norhagen et al., 2024). The resulting five core dimensions, which provide the foundational structure for both the survey and interview protocol, are: (1) Digital Pedagogy and Learning Design, (2) Digital Resource Management and Creation, (3) Digital Assessment and Feedback, (4) Professional Engagement and Collaboration in Digital Environments, and (5) Ethical and Responsible Digital Citizenship in Education.

Sub-Dimension / Focus Area

The ensure a thorough and nuanced assessment of Teacher Digital Competence, each of the five core dimensions introduced in the preceding section, Digital Pedagogy and Learning Design; Digital Resource Management and Creation; Digital Assessment and Feedback; Professional Engagement and Collaboration in Digital Environments; and Ethical and Responsible Digital Citizenship in Education has been further delineated into specific sub-dimensions or key focus areas. This level of granularity is critical for translating the broader conceptual dimensions into measurable indicators and for guiding the development of specific items within the survey and targeted questions for the interview protocol. The identification of these sub-dimensions was an integral part of the conceptual framework development, informed by a detailed analysis of the components and facets highlighted within the foundational literature, and the detailed competency areas within frameworks like DigCompEdu and INTEF), as well as by recurring themes identified in systematic reviews of TDC concerning common areas of digital teaching practice and responsibilities (Pinto-Santos et al., 2022). This detailed breakdown, presented in Table [Insert Table Number here], aims to provide a clear and actionable map of a teacher's digital capabilities and forms the precise thematic structure for both the survey and interview instruments.

Table 1. *Core TDC Dimensions and Associated Sub-Dimensions*

Core TDC Dimension	Sub-Dimensions
Digital Pedagogy & Learning Design	Designing inclusive digital learning; Integrating digital tools for instruction; Facilitating student-centered tech use; Adapting digital pedagogy.
Digital Resource Management & Creation	Finding & evaluating digital resources; Creating & adapting digital content; Organizing & sharing resources; Copyright & open licensing.

Core TDC Dimension	Sub-Dimensions
Digital Assessment & Feedback	Using digital tools for assessment; Designing digital assessment strategies; Providing digital feedback; Analyzing digital assessment data.
Professional Engagement & Collaboration in Digital Environments	Digital communication with stakeholders; Online professional collaboration; Digital tools for professional learning; Digital communication with students & parents.
Ethical & Responsible Digital Citizenship in Education	Ensuring student online safety, data privacy, and Promoting online safety & wellbeing; Ensuring data privacy & security; Fostering critical digital literacy; Modeling ethical online behavior; Managing professional digital identity.

The first dimension, Digital Pedagogy and Learning Design, reflects teachers' ability to design inclusive and effective digital learning experiences. This includes competencies in meaningfully integrating technology into instructional processes, utilizing digital tools to support student-centered learning, and adapting pedagogical approaches to suit specific learning needs and contexts. The second dimension, Digital Resource Management and Creation, focuses on teachers' skills in locating, evaluating, and creating relevant digital content for teaching and learning. It also encompasses the ability to organize and share digital resources effectively, as well as understanding copyright, open licensing, and the ethical use of digital materials. The third dimension, Digital Assessment and Feedback, assesses the extent to which teachers can design and implement assessment strategies using digital tools. This includes using digital technologies for both formative and summative assessments, developing appropriate digital assessment approaches, providing constructive digital feedback, and analyzing digital assessment data to enhance learning outcomes. The fourth dimension, Professional Engagement and Collaboration in Digital Environments, emphasizes teachers' engagement in building professional communication and collaboration in digital spaces. Sub-dimensions include effective communication with stakeholders (including students and parents), online collaboration with peers, using digital platforms for ongoing professional development, and leveraging digital media to build professional networks. Finally, the fifth dimension, Ethical and Responsible Digital Citizenship in Education, represents teachers' responsibilities in fostering a safe, ethical, and critically aware digital learning environment. This involves ensuring students' online safety and well-being, maintaining data privacy and security, promoting critical digital literacy, modeling ethical behavior in technology use, and managing their professional digital identity with integrity and responsibility. These five dimensions collectively form the core conceptual framework underpinning the development of instruments for mapping Teacher Digital Competence (TDC), applicable to both the quantitative survey and qualitative interview protocol.

Operationalization of the Framework into Survey and Interview Instruments

The conceptual framework, with its five core Teacher Digital Competence (TDC) dimensions and associated sub-dimensions as detailed in Table 1, provides the direct architectural blueprint for both the quantitative survey and the qualitative interview protocol. This systematic operationalization ensures that each instrument comprehensively addresses the multifaceted nature of TDC as conceptualized from foundational literature including the holistic, the recurring aspect, and established frameworks like DigCompEdu, INTEF, and COMDID (Falloon, 2020; Peters et al., 2022; Yang, 2024). For the survey instrument, each sub-dimension identified under the core dimensions in Table 1 was translated into specific

items designed to measure teachers' self-perceived competence, frequency of practice, or relevant attitudes. This translation predominantly utilized Likert-type scales and frequency scales, aligning with established TDC assessment methodologies (Zhang et al., 2024). The aim was to develop multiple items per sub-dimension where appropriate to ensure robust coverage, thereby enabling a quantitative mapping of TDC across the full spectrum of the framework. Table 2 provides an illustrative breakdown of how each core dimension and its sub-dimensions (from Table 1) are approached within the survey, indicating the focus of measurement and example item stems.

The interview protocol was structured thematically around the five core TDC dimensions and their constituent sub-dimensions outlined in Table 1, transforming them into key areas of qualitative inquiry. Rather than generating fixed-choice items, the framework guided the development of open-ended questions and illustrative probes designed to elicit rich, narrative accounts of teachers' experiences, pedagogical reasoning, and the contextual nuances influencing their digital competence. This approach, consistent with effective qualitative educational research practices that seek deep experiential understanding, allows for an exploration of the "how" and "why" behind observed practices and self-perceptions. The interview thereby seeks to gather in-depth data on each dimension, such as the practical application of ethical considerations in digital environments or the intricate decision-making processes involved in designing digitally-enhanced learning activities. Table 3 further illustrates how each core dimension from Table 1 is explored through specific areas of inquiry and example questions within the semi-structured interview protocol, highlighting its role in complementing the survey by providing depth and context.

Discussion

The further elucidate the distinctive characteristics and contributions of the proposed instrument suite, a comparative overview with selected existing frameworks and instruments is presented in Table [Insert New Table Number, corresponding to the table you just created]. This tabular representation is designed to offer readers a clear and accessible means of discerning the key differences and similarities in terms of primary theoretical underpinnings, the core dimensions or factors assessed, the methodological approaches employed, and the primary target populations for which these tools were developed. By systematically juxtaposing these elements, the table aims to visually underscore the unique positioning of the proposed instrument within the broader landscape of Teacher Digital Competence assessment. Such a comparison is intended to facilitate a more immediate understanding of how the current proposal builds upon, and also diverges from, prior scholarly efforts in this domain, thereby highlighting its specific novelties and potential contributions to the field. Ultimately, this structured overview serves to complement the preceding narrative discussion by providing a concise, at-a-glance summary of the instrument's conceptual and methodological architecture in relation to established and contemporary TDC assessment tools.

The proposed Teacher Digital Competence (TDC) instrument suite is a mixed-method tool designed specifically for in-service K–12 teachers, integrating a quantitative survey and a qualitative semi-structured interview. It is theoretically grounded in a synthesis of several prominent frameworks, DigCompEdu, INTEF, and COMDID (Skantz-Åberg et al., 2022; Falloon, 2020).

Table 2. *Comparative Overview of the Proposed TDC Instrument Suite*

Key Feature	Proposed Instrument Suite	DigCompEdu	INTEF	COMDID Framework & Instruments
Primary Theoretical Basis/Origin	Synthesis of Falloon (2020), Skantz-Åberg et al. (2022), DigCompEdu, INTEF, COMDID.	European Commission; Redecker & Punie, 2017 (as cited in Peters et al., 2022).	Spain's Common Framework of Digital Competence for Teachers.	COMDID framework; Academic Research (e.g., Lázaro Cantabrana et al., 2019; Usart Rodríguez et al., 2021).
Core Dimensions/ Factors Assessed	Five core dimensions: 1. Digital Pedagogy & Learning Design; 2. Digital Resource Management & Creation; 3. Digital Assessment & Feedback; 4. Professional Engagement & Collaboration; 5. Ethical & Responsible Digital Citizenship in Education; each with sub-dimensions.	Areas: Digital Resources, Teaching & Learning, Assessment, Empowering Learners, Facilitating Learners' Digital Competence; general areas of professional engagement, resources, teaching, assessment.	Areas: Information & data literacy, communication & collaboration, digital content creation, safety, problem-solving.	Focuses on didactic, planning, ethical, & professional development aspects.
Methodology/ Approach	Mixed-method: quantitative survey & qualitative semi-structured interview.	Framework.	Framework.	COMDID-A: Self-evaluation tool; COMDID-C: Knowledge-based test.
Target Population	In-service K-12 teachers.	Educators (general).	Teachers.	Pre-service teachers (COMDID-C); Teachers (COMDID-A).

The suite assesses five core dimensions—Digital Pedagogy and Learning Design, Digital Resource Management and Creation, Digital Assessment and Feedback, Professional Engagement and Collaboration, and Ethical and Responsible Digital Citizenship—each with detailed sub-dimensions to provide a comprehensive picture of TDC. Compared to existing models such as DigCompEdu (developed by the European Commission), INTEF (Spain's national framework), and the COMDID instruments (which target pre-service and in-service teachers through self-evaluation and knowledge-based tools), the proposed instrument offers a more integrated and context-sensitive approach. While DigCompEdu and INTEF primarily function as frameworks for teacher competence in broader terms, and COMDID focuses on didactic and ethical aspects, the proposed suite stands out in its mixed-method design and its specific focus on capturing both the perception and practice of digital competence in classroom settings.

Overview of the Proposed Instrument and Its Conceptual Underpinnings

The preceding Results section detailed the architecture of a newly proposed instrument suite, comprising a quantitative survey and a qualitative semi-structured interview protocol, designed for the comprehensive mapping of Teacher Digital Competence (TDC) in K-12 in-service educators. Central to this design is a conceptual framework articulating TDC across five core dimensions: (1) Digital Pedagogy and Learning Design, (2) Digital Resource Management and Creation, (3) Digital Assessment and Feedback, (4) Professional Engagement and Collaboration in Digital Environments, and (5) Ethical and Responsible Digital Citizenship in Education. As elaborated in the Method section, the development of this

framework, and consequently the structure of the proposed instruments, was not undertaken in isolation but was systematically synthesized from an extensive review of contemporary literature. This synthesis drew significantly from the holistic perspective offered Teacher Digital Competency (TDC) framework, the empirically identified recurring conceptual aspects of TDC and the structural insights from influential established frameworks such as the European Framework for the Digital Competence of Educators (Al Shabibi , 2021). The spain's Common Framework of Digital Competence for Teachers and the COMDID framework (Nurhalisa et al., 2021). This deliberate grounding in existing scholarly work ensures the proposed instrument suite is both theoretically informed and aims to address the complex, multifaceted nature of digital competence required in contemporary educational settings, providing a foundation for the ensuing discussion on its relationship with existing literature and its potential contributions.

Interpretation and Comparison with Existing Literature and Frameworks

1. Situating the Instrument within the TDC Landscape

The five-dimensional conceptual framework underpinning the proposed instrument suite—encompassing Digital Pedagogy & Learning Design, Digital Resource Management & Creation, Digital Assessment & Feedback, Professional Engagement & Collaboration, and Ethical & Responsible Digital Citizenship, reflects a synthesis of several influential perspectives in Teacher Digital Competence (TDC) research. The emphasis on a holistic understanding aligns significantly TDC framework, which argues for moving beyond mere technical skills to include broader pedagogical, ethical, and professional capabilities. Similarly, the dimensions resonate with the seven recurring aspects, such as pedagogical competence, professional engagement, and having a critical approach, suggesting that our instrument aims to capture these widely recognized facets of teacher competence. Furthermore, the framework for our proposed instrument engages directly with established European standards such as the European Framework for the Digital Competence of Educators (DigCompEdu). As noted in various systematic reviews and studies, DigCompEdu has become a pivotal reference, and our dimensions, while distinct in their configuration, cover many of its core areas like 'Digital Resources,' 'Teaching and Learning,' 'Assessment,' 'Empowering Learners,' and 'Facilitating Learners' Digital Competence.' Specifically, our 'Digital Pedagogy & Learning Design' and 'Digital Assessment & Feedback' dimensions correspond to key areas within DigCompEdu, while 'Professional Engagement & Collaboration' and 'Ethical & Responsible Digital Citizenship' extend to capture professional and societal responsibilities also highlighted by frameworks like Falloon's.

The instrument's structure also finds parallels and offers distinctions when compared to national frameworks like Spain's Common Framework of Digital Competence for Teachers (INTEF), typically includes areas such as information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving. While our 'Digital Resource Management & Creation' aligns with INTEF's content creation and information literacy, and 'Professional Engagement & Collaboration' mirrors communication and collaboration, our proposed dimension of 'Ethical & Responsible Digital Citizenship' aims to provide a perhaps more expansive view than 'Safety' alone, encompassing broader societal and ethical considerations crucial for 21st-century educators. Moreover, the COMDID framework, often focuses on didactic, planning, ethical, and professional development aspects. Our five dimensions seek to integrate these in a structured manner, with 'Digital Pedagogy & Learning Design' covering didactic and planning aspects, and 'Professional Engagement' alongside

'Ethical & Responsible Digital Citizenship' addressing the professional and ethical components. The intent of our framework is to provide a comprehensive yet distinct model that integrates these varied perspectives into a coherent structure for mapping TDC in K-12 in-service teachers.

2. Comparison with Existing TDC Assessment Instruments

Beyond conceptual frameworks, the proposed instrument suite combining a survey and a semi-structured interview protocol can be compared with existing TDC assessment tools. The TDC-S developed by Aydin et al. (2024), for instance, offers a validated four-factor scale (Teachers' Professional Digital Competence; Teachers' Use of Instructional and Communication Tools; Teachers' Use of Hardware Tools; Teachers' Digital Content Development). While both our survey and the TDC-S draw inspiration from DigCompEdu and aim for comprehensive assessment, our five-dimension model offers a different categorization of competencies, with potentially more explicit emphasis on 'Digital Pedagogy & Learning Design' as a distinct area from general professional competence, and a dedicated dimension for 'Ethical & Responsible Digital Citizenship'. Furthermore, our inclusion of an interview protocol is designed to complement the self-perception data gathered by the survey, addressing the predominance of quantitative self-assessment tools, thereby aiming for richer, more contextualized data. The INTEF framework, distinguishes between 'Knowledge' and 'Use' scales; our survey primarily focuses on self-perceived competence and frequency of practice, with the interview intended to explore the depth of knowledge and its application.

The COMDID-A self-evaluation tool, validated by Usart Rodríguez et al. (2021), and the knowledge-based COMDID-C instrument offer another point of comparison. While our survey shares the self-assessment nature of COMDID-A, our broader five-dimension structure and the addition of the interview protocol aim for a more holistic mapping than a single instrument might provide. Systematic reviews such as those highlight a landscape often characterized by quantitative instruments; our proposed mixed-method suite attempts to address calls for more nuanced assessment that can capture the complexity of TDC (Ma & Ismail, 2025). Moreover, while many instruments focus on higher education or pre-service teachers our instrument is specifically designed for in-service K-12 teachers, a context that requires tools tailored to their specific professional realities and development needs (Skantz-Åberg et al., 2022). The structure of TDC explored by Yang (2024), with its six subscales (Security, Data Literacy, Problem-Solving, Digital Content Creation, Communication and Cooperation, Ethics), also provides a useful comparative lens, with our five dimensions offering a potentially different, albeit related, conceptual grouping for these competencies. The overarching goal of our proposed suite is to build upon these existing efforts by offering a conceptually robust and methodologically rich approach to comprehensively mapping the evolving construct of TDC.

Contributions and Novelty of the Proposed Instrument Suite

The proposed Teacher Digital Competence (TDC) mapping suite makes several notable contributions to the existing landscape of TDC assessment. Firstly, its five-dimensional conceptual framework (Digital Pedagogy & Learning Design; Digital Resource Management & Creation; Digital Assessment & Feedback; Professional Engagement & Collaboration; and Ethical & Responsible Digital Citizenship) offers a comprehensive and contemporary operationalization of TDC. This structure is intentionally holistic, drawing inspiration from broad conceptualizations TDC framework, which advocates for moving beyond mere technical proficiencies, and aims to encompass the multifaceted aspects of teachers' professional digital competence, like pedagogical competence, professional engagement, and a critical approach.

This holistic design responds to calls from broader overviews of the field, which highlighted the need for more integrated and transversal perspectives in TDC research and development, moving beyond fragmented or purely technical views of competence. The instrument suite, therefore, aims to provide a more rounded and pedagogically-centered map of teachers' capabilities in the digital age (Peters et al., 2022).

The significant novelty of this proposed instrument suite lies in its mixed-methodological approach, integrating a quantitative survey with a qualitative semi-structured interview protocol. This addresses a noted predominance of, and potential limitations associated with, solely quantitative self-assessment tools in TDC research. While the survey component allows for a broad mapping of self-perceived competencies and practices, the inclusion of the interview protocol is designed to capture the rich contextual nuances, the underlying pedagogical reasoning, and the lived experiences of teachers (Aydin & Yildirim, 2022) . This qualitative dimension, offers the potential to explore deeper aspects of TDC, such as teachers' understanding of digitalization's impact on epistemic practices or their strategies for navigating complex ethical dilemmas, which are often challenging to assess through closed-ended survey items alone.

The explicit and detailed focus on the 'Ethical & Responsible Digital Citizenship in Education' dimension is a key contribution. While existing frameworks like INTEF include 'Safety,' and DigCompEdu addresses aspects of responsible use, our proposed dimension seeks a more expansive treatment, incorporating elements of digital wellbeing, critical media literacy, data privacy, and the modeling of ethical online behavior for students. This comprehensive approach to digital citizenship is particularly crucial in light of the increasing societal and educational demands for ethically aware and responsible digital actors. This focus may also contribute to addressing areas that some bibliometric and systematic reviews suggest are emerging or require deeper investigation within the broader TDC discourse by providing specific means to assess these critical competencies.

The specific targeting of in-service K-12 teachers also represents a valuable contribution, as many existing studies and instruments tend to focus on pre-service teacher populations, or higher education faculty (Zhang et al., 2024; Peters et al., 2022; Basilotta-Gómez-Pablos et al., 2022). While insights from these contexts are informative, the professional realities, existing skill sets, and development needs of practicing K-12 teachers can differ significantly. By providing a tool specifically designed with this demographic in mind, the proposed suite aims to offer more relevant and actionable data for professional development initiatives tailored to the unique challenges and opportunities within primary and secondary education. This aligns with the general need for robust assessment tools to understand and improve TDC across all educational levels (de los Ángeles Domínguez-González et al., 2025; Butar et al., 2024).

This instrument suite is presented as a foundational resource, intended to contribute to both research and practice. By offering a detailed and theoretically grounded blueprint for mapping Teacher Digital Competence, it aims to equip researchers with a tool to investigate TDC more comprehensively and to provide educational practitioners and policymakers with reliable data to inform the design and evaluation of effective professional development programs. The consistent finding across various studies that TDC levels often require underscores the ongoing need for validated and nuanced assessment instruments enhancement (Al Shabibi, 2022; de los Ángeles Domínguez-González et al., 2025). The proposed suite, once empirically validated, seeks to fulfill this need by providing a versatile

and comprehensive means of understanding and fostering teacher digital competence for the betterment of teaching and learning in the 21st century.

Contributions and Novelty of the Proposed Instrument Suite

1. Implications for Professional Development

The proposed Teacher Digital Competence (TDC) mapping suite holds significant practical implications for the design and implementation of effective teacher professional development. A primary application of this instrument suite is its capacity to identify specific areas where in-service K-12 teachers may require targeted support, thereby facilitating a shift from generic training to more personalized learning pathways. The highlighted particular areas of TDC where teachers report significant training needs. Our instrument, by providing a detailed competency profile across its five dimensions, can offer a precise diagnosis of these specific needs for individual teachers or identified groups within an educational institution. Furthermore, considering the findings from systematic reviews, which indicate that professional development interventions often target particular areas such as digital technology and resources, this suite offers a valuable tool for informing such focused support (Zhang et al., 2024).

The capacity of our suite to help determine baseline competencies can greatly assist in tailoring these interventions effectively and subsequently measuring their impact upon teachers' digital practices. This aligns with the principle, that a thorough understanding of current TDC levels is crucial for fostering meaningful and sustainable improvement (Butar et al., 2024). Moreover, the detailed qualitative data from the interview protocol can, in particular, uncover the pedagogical reasoning and contextual challenges behind certain competency levels, allowing professional development providers to tailor programs that are not only skills-focused but also address teachers' beliefs, attitudes, and specific classroom realities, as suggested by holistic frameworks. By offering such a comprehensive map, the instrument can empower teachers to take ownership of their professional growth. Ultimately, this enables educational institutions to allocate resources more effectively for truly impactful training initiatives that cater to diagnosed needs.

2. Implications for Educational Policy and Mapping Studies

Beyond individual professional development, the proposed instrument suite has valuable implications for broader educational policy and large-scale TDC mapping initiatives. Educational authorities and policymakers require robust data to inform decisions regarding digital education strategies, curriculum development, and teacher competency standards. Our instrument can serve as a tool for conducting comprehensive mapping studies at regional or national levels, providing empirical evidence on the current state of TDC among K-12 in-service teachers. This aligns with the increasing focus on digital competence in education policy globally, as noted in various international frameworks and reviews (Peters et al., 2022). The data generated can help benchmark competencies, identify systemic gaps, and track the progress of policy interventions aimed at enhancing TDC. Furthermore, understanding the nuances of TDC across different dimensions, including 'Ethical & Responsible Digital Citizenship,' can inform the development or refinement of national teacher standards to better reflect the complex demands of teaching in the digital age in conceptualizing TPDC (Skantz-Åberg et al., 2022). The instrument's capacity to provide both quantitative and qualitative data makes it particularly useful for generating nuanced insights that can lead to more informed and effective educational policies.

3. Implications for Future TDC Research

The proposed instrument suite also offers considerable potential for advancing future research in the field of Teacher Digital Competence. As a new, comprehensive tool designed for K-12 in-service teachers, it can be employed in various research designs to explore numerous unanswered questions. For example, it can be used to investigate the relationships between TDC (as measured by the suite) and a range of other variables, such as teacher demographics, years of experience, subject taught, school context, and, crucially, student learning outcomes, in different contexts (Yang, 2024). The mixed-method nature of the suite allows for both the statistical analysis of trends and the in-depth qualitative exploration of underlying mechanisms, addressing calls from reviews for more nuanced research approaches that move beyond solely self-assessment surveys (Ma & Ismail, 2025; Peters et al., 2022). Longitudinal studies utilizing this instrument could track the development of TDC over time, perhaps in response to specific interventions or policy changes. Moreover, the instrument can facilitate comparative research across different educational systems or teacher populations, contributing to a more global understanding of TDC, a need that implicitly arises from bibliometric studies covering diverse geographical research outputs (Aydin & Yildirim, 2022; Butar et al., 2024). The detailed blueprint of the instrument, grounded in contemporary TDC conceptualizations, also provides a basis for further scholarly discussion and refinement of TDC assessment methodologies.

Limitations of the Proposed Instrument and Current Study

This paper presents a comprehensively designed and theoretically grounded suite of instruments for mapping Teacher Digital Competence (TDC), several limitations inherent to this stage of development must be acknowledged. The most significant limitation is that the proposed survey and interview protocol are, at present, conceptual blueprints; they have not yet undergone the rigorous empirical validation process required to establish their psychometric properties and practical utility in diverse real-world settings. Consequently, claims regarding their effectiveness for accurately mapping TDC remain provisional until such validation is completed. This includes establishing content validity through expert reviews, assessing construct validity via techniques like factor analysis for the survey, and determining reliability metrics such as internal consistency, all of which are planned as crucial subsequent steps.

The further consideration pertains to the nature of the data collection methods proposed. The survey instrument, while designed to be comprehensive, relies significantly on teacher self-perception to gauge competence, attitudes, and practices. Although this is a common and valuable approach in TDC assessment, and often used in instruments, self-reported data can be subject to biases, such as social desirability or variations in self-awareness. The inclusion of the qualitative interview protocol is intentionally designed to mitigate this by providing deeper, contextualized insights and allowing for a degree of triangulation. However, the field has seen calls to move beyond a heavy reliance on self-assessment, underscoring the importance of interpreting the survey data cautiously until it is complemented by qualitative findings and, ideally, other forms of evidence in future research.

The scope of the current conceptual framework and the resulting instrument, while aiming for comprehensiveness is also subject to limitations. The instrument is specifically designed for in-service K-12 teachers, and its direct applicability to other educational contexts, such as higher education or pre-service teacher training, without adaptation and re-validation, cannot be assumed. Moreover, while the framework draws from internationally recognized models

like DigCompEdu and INTEF, the initial development context (even if broadly literature-based) might carry implicit cultural or systemic assumptions. Therefore, future validation efforts would need to consider its applicability and potential need for adaptation across diverse cultural and educational systems to ensure its global relevance.

Finally, the construct of Teacher Digital Competence itself is dynamic and continuously evolving, influenced by rapid technological advancements and changing pedagogical paradigms, as suggested by the ongoing discussions and varied conceptualizations in the literature (Skantz-Åberg et al., 2022; Ma & Ismail, 2025). Any instrument designed to measure TDC, including the one proposed herein, captures a snapshot within this evolving landscape. Thus, periodic review and potential revision of the instrument will be necessary in the future to maintain its relevance and ensure it continues to reflect contemporary understandings and requirements of what it means for a teacher to be digitally competent. Addressing these limitations proactively in the subsequent validation and refinement phases will be crucial for developing this suite into a truly robust and impactful tool for the field.

Future Research: Empirical Validation and Refinement

The presentation of this newly designed Teacher Digital Competence (TDC) mapping suite, with its comprehensive five-dimensional framework and dual-instrument approach, represents a foundational step. However, as emphasized throughout this paper and particularly in the limitations, the immediate and most critical direction for future research is the rigorous empirical validation of both the survey instrument and the semi-structured interview protocol. This subsequent phase is indispensable before the instruments can be confidently deployed for broad mapping studies or to inform the design and evaluation of professional development initiatives. The validation process will need to be multifaceted, drawing upon established psychometric and qualitative research methodologies to ensure the reliability and validity of the data gathered. For instance, the validation of the survey will necessitate expert reviews by TDC scholars and experienced K-12 educators to establish content validity, ensuring that the items and sub-dimensions accurately reflect the intended constructs outlined in Table 1. This will be followed by pilot testing with a representative sample of in-service K-12 teachers to assess clarity, identify any problematic items, and gather initial data for psychometric analysis.

Subsequent statistical analyses for the survey instrument will need to include Exploratory Factor Analysis (EFA) to examine the underlying factor structure and Confirmatory Factor Analysis (CFA) to test the fit of the proposed five-dimensional model, similar to the robust validation processes undertaken for instruments such as the TDC-S, the INTEF-based questionnaire, or the COMDID-A tool as validated. Internal consistency reliability for each dimension and the overall scale will be assessed using measures like Cronbach's Alpha and composite reliability. For the interview protocol, pilot testing will focus on refining the clarity and appropriateness of questions and probes, ensuring they effectively elicit rich, relevant data across the five core TDC dimensions; establishing inter-rater reliability for qualitative coding procedures will also be essential. Insights from existing studies that have successfully developed and validated TDC instruments will provide valuable methodological guidance for these processes.

Beyond initial validation, further research should explore the instrument suite's utility across diverse K-12 contexts, considering variables such as school demographics, teacher experience levels, and subject specializations, to ensure its broader applicability. The need for such context-sensitive assessment is often highlighted. Longitudinal studies employing the

validated instruments could provide invaluable insights into how teachers' digital competence evolves over time, perhaps in response to specific professional development programs identified as effective in reviews, or as they engage with the ever-changing technological landscape (Nagel, 2021). Ultimately, this rigorous path of validation and refinement is crucial to realizing the potential of this instrument suite as a valuable tool for understanding and fostering Teacher Digital Competence.

Conclusion

The results of this study present a conceptual framework and initial design for a newly developed, comprehensive instrument suite aimed at mapping the multidimensional digital competence of in-service K–12 teachers. This instrument suite comprises a quantitative survey and a semi-structured qualitative interview protocol, both of which are structured around five core dimensions: Digital Pedagogy and Learning Design, Digital Resource Management and Creation, Digital Assessment and Feedback, Professional Engagement and Collaboration in Digital Environments, and Ethical and Responsible Digital Citizenship in Education. The framework was developed through a theoretical synthesis that integrates various contemporary models and literature, with the goal of operationalizing the complex construct of teacher digital competence into a measurable and context-sensitive format.

The use of a mixed-methods approach enables a more holistic exploration by combining broad self-perception data obtained from the survey with deeper, contextual insights from the interviews. This approach offers a richer alternative to single-method assessments, which often provide limited perspectives. However, a key limitation of this study is that the instrument suite remains at the conceptual stage, and has yet to undergo empirical validation to ensure its reliability and applicability across diverse educational contexts. Therefore, this study strongly recommends comprehensive validation procedures, including expert content reviews, pilot testing with target teacher groups, and psychometric analyses such as validity and reliability testing. Once validated, this instrument suite holds significant potential as a valuable tool in digital education research, particularly for large-scale competence mapping, evaluating professional development programs, and designing data-driven interventions to enhance teaching and learning in digitally enriched environments.

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References

Al Shabibi, A., & Al Shabibi, T. (2021, December). Teachers' training needs for digital competences. In *2021 22nd International Arab Conference on Information Technology (ACIT)* (pp. 1-7). IEEE. https://doi.org/10.1109/ACIT53391.2021.9677227

Aydin, M. K., & Yildirim, T. (2022). Teachers'digital Competence: Bibliometric Analysis Of The Publications Of The Web Of Science Scientometric Database. *Information Technologies and Learning Tools*, *91*(5), 205. https://doi.org/10.33407/itlt.v91i5.5048

Basilotta-Gómez-Pablos, V., Matarranz, M., Casado-Aranda, L. A., & Otto, A. (2022). Teachers' digital competencies in higher education: a systematic literature review. *International journal of educational technology in higher education*, *19*(1), 8. https://doi.org/10.1186/s41239-021-00312-8

Butar, S. B., Haniva, R., & Mulyadi, H. (2024). Research trends in teacher digital competencies: A bibliometric review. *Jurnal Varidika*, 31-49. https://doi.org/10.23917/varidika.v36i1.4993

de los Ángeles Domínguez-González, M., de la Rosa, A. L., Hervás-Gómez, C., & Román-Graván, P. (2025). Teacher Digital Competence: Keys for an Educational Future through a Systematic Review. *Contemporary Educational Technology*, *17*(2).

Esteve-Mon, F., Llopis-Nebot, M., Viñoles-Cosentino, V., & Adell-Segura, J. (2022). Digital teaching competence of university teachers: levels and teaching typologies. *International Journal of Emerging Technologies in Learning (iJET)*, *17*(13), 200-216.

Falloon, G. (2020). From digital literacy to digital competence: the teacher digital competency (TDC) framework. *Educational technology research and development*, *68*(5), 2449-2472. https://doi.org/10.1007/s11423-020-09767-4

Gisbert Cervera, M., & Caena, F. (2022). Teachers' digital competence for global teacher education. *European Journal of Teacher Education*, *45*(4), 451-455. https://doi.org/10.1080/02619768.2022.2135855

Gómez-Trigueros, I. M., de Atalaya, S. P. L., & Ros, R. D. (2021). Towards an insertion of technologies: The need to train in digital teaching competence. *International and Multidisciplinary Journal of Social Sciences*, *10*(3), 64-87. https://doi.org/10.17583/rimcis.8652

Lázaro Cantabrana, J. L., Usart Rodríguez, M., & Gisbert Cervera, M. (2019). Assessing teacher digital competence: The construction of an instrument for measuring the knowledge of pre-service teachers. *Journal of new approaches in educational research*, *8*(1), 73-78. https://doi.org/10.7821/naer.2019.1.370

Ma, H., & Ismail, L. (2025). Bibliometric analysis and systematic review of digital competence in education. *Humanities and Social Sciences Communications*, *12*(1), 1-17. https://doi.org/10.1057/s41599-025-04401-1

Nagel, I. (2021). Digital competence in teacher education curricula: What should teacher educators know, be aware of and prepare students for?. *Nordic Journal of Comparative and International Education (NJCIE)*, *5*(4), 104-122. https://doi.org/10.7577/njcie.4228

Norhagen, S. L., Krumsvik, R. J., & Røkenes, F. M. (2024, April). Developing professional digital competence in Norwegian teacher education: a scoping review. In *Frontiers in Education* (Vol. 9, p. 1363529). Frontiers Media SA. https://doi.org/10.3389/feduc.2024.1363529

Nurhalisa, S., Ma'rufi, M., & Baharuddin, M. R. (2021). Pengembangan Media Pembelajaran Berbasis Asesmen Kompetensi Minimum dan Pemecahan Masalah. *Jurnal Literasi Digital*, *1*(3), 192–202. https://doi.org/10.54065/jld.1.3.2021.63

Peters, M., Ejjaberi, A. E., Martínez, M. J., & Fàbregues, S. (2022). Teacher digital competence development in higher education: Overview of systematic reviews. *Australasian Journal of Educational Technology*, *38*(3), 122-139. https://doi.org/10.14742/ajet.7543

Pinto-Santos, A. R., Pérez Garcias, A., & Darder Mesquida, A. (2022). Development of Teaching Digital Competence in Initial Teacher Training: A Systematic Review. *World Journal on Educational Technology: Current Issues*, *14*(1), 1-15.

Skantz-Åberg, E., Lantz-Andersson, A., Lundin, M., & Williams, P. (2022). Teachers' professional digital competence: An overview of conceptualisations in the literature. *Cogent Education*, *9*(1), 2063224. https://doi.org/10.1080/2331186X.2022.2063224

Yang, H. (2024). From digital literacy to digital competence: The structure of Teacher Digital Competence (TDC). *Innovations in Education and Teaching International*, 1-13. https://doi.org/10.1080/14703297.2024.2437675

Zhang, X., Sazalli, N. A. H., Miskam, N. N., & Nadjwa, N. (2024). Improving Teachers' Digital Competence in Higher Education: A Systematic Literature Review. *International Journal Of Academic Research In Progressive Education And Development*, *1*, 3. http://dx.doi.org/10.6007/IJARPED/v13-i1/20560