

Unpacking Pedagogical Knowledge of Inclusive Learning Design Among Indonesian Pre-Service Science Teachers

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As science classrooms grow increasingly diverse, understanding how pre-service science teachers design inclusive learning has become a critical concern, particularly in the Indonesian context, where teacher preparation for inclusivity remains underdeveloped. The present study explores the pedagogical knowledge of 263 Indonesian pre-service science teachers using an integrated framework of Technological Pedagogical Content Knowledge, Backward Design, and Universal Design for Learning. Employing a mixed-methods sequential explanatory design, we collected quantitative data via surveys and qualitative insights from interviews with 16 participants. The results show that while participants report high levels of conceptual knowledge across all three frameworks, challenges persist in translating that knowledge into practice, especially in differentiating assessments, setting inclusive learning goals and integrating technology responsively. Teaching experience significantly influenced knowledge application, whereas gender and prior interaction with students with special education needs and disabilities did not yield significant differences. These findings highlight the need for structured, practice-based coursework and reflection within teacher education programmes in order to close the gap between inclusive ideals and classroom realities.

Keywords: Backward Design, inclusive science learning, Universal Design for Learning, Technological Pedagogical Content Knowledge

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Raziskava pedagoškega znanja o inkluzivnem načrtovanju poučevanja med indonezijskimi bodočimi učitelji naravoslovja

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☞ Ker so razredi pri pouku naravoslovja vedno bolj raznoliki, je razumevanje, kako bodoči učitelji naravoslovja načrtujejo inkluzivno poučevanje, postalo kritično pomembno, zlasti v indonezijskem kontekstu, v katerem je priprava učiteljev na inkluzijo še vedno premalo razvita. Ta študija raziskuje pedagoško znanje 263 indonezijskih bodočih učiteljev naravoslovja z uporabo integriranega okvira tehnološko-pedagoškega znanja o vsebini, nazaj usmerjenega oblikovanja in univerzalnega načrtovanja za učenje. Z uporabo zaporednega razlagalnega modela z mešanimi metodami smo zbrali kvantitativne podatke prek anket in kvalitativne vpoglede iz intervjujev s 16 udeleženci. Izsledki kažejo, da udeleženci sicer poročajo o visoki ravni konceptualnega znanja v vseh treh okvirih, vendar ostajajo izzivi pri prenosu tega znanja v prakso, zlasti pri razlikovanju ocenjevanja, postavljanju inkluzivnih učnih ciljev in pri odzivnem vključevanju tehnologije. Izkušnje s poučevanjem so pomembno vplivale na uporabo znanja, medtem ko spol in predhodna interakcija z učenci s posebnimi učnimi potrebami in invalidnostjo nista prinesla pomembnih razlik. Te ugotovitve poudarjajo potrebo po strukturiranih, na praksi temelječih študijskih programih in refleksiji v okviru programov izobraževanja učiteljev, da se zapolni vrzel med inkluzivnimi ideali in resničnostjo v razredu.

Ključne besede: nazaj usmerjeno oblikovanje, inkluzivno učenje naravoslovja, univerzalno načrtovanje za učenje, tehnološko-pedagoško znanje o vsebini

Introduction

Science teachers play a fundamental role in the success of inclusive science education; however, they face challenges in addressing diversity and inclusion effectively (Mamluk-Naaman, 2024). In many cases, inclusive education is reduced to the physical presence of students with special education needs and disabilities (SEND) in mainstream classrooms, without the necessary pedagogical and accessible support. This understanding tends to overlook the importance of addressing each student's unique learning needs (Suprihatiningrum et al., 2022). In contrast, authentic inclusive education entails more than just access; it encompasses equitable opportunities for diverse students, responsiveness to individual differences (Ainscow, 2020; Florian & Black-Hawkins, 2011), a supportive learning environment (Nijakowska, 2022), active participation, and the cultivation of a genuine sense of belonging within the learning community (Sanger, 2020).

As the primary agents of inclusive practice, teachers play a crucial role in guiding each student towards achieving meaningful academic success. This involves not only setting high expectations for all learners (Rubie-Davies, 2010) but also providing sustained support to students facing diverse learning challenges (Eklund et al., 2020; Shevchenko et al., 2020). Science teachers need to believe that all students can learn and progress. This can be realised when teachers use “particular teaching methods”, “have high expectations for all students”, and “create [a] positive student-teacher relationship” (Hattie, 2009, p. 126). These competencies need to be cultivated from the pre-service teacher preparation programme.

A preliminary review of pre-service curriculum programmes in Indonesia reveals that inclusive learning is addressed in only one course, an elective entitled *Introduction to Education for Children with Special Needs* (Ministry of Education and Culture of Indonesia, 2022). This limited exposure suggests that pre-service science teachers are often inadequately prepared to teach in inclusive classrooms. In contrast, Wang and Shih (2022) emphasised the key role of teachers in upholding students' rights to education, highlighting the necessity for future educators to be equipped to address diverse learner needs. Accordingly, the structure of pre-service teacher education programmes warrants critical examination, particularly concerning how curricular design and requirements can more effectively foster knowledge and competence in inclusive education (Massouti, 2021). A lack of training in inclusive practices has been identified as a major barrier for newly qualified teachers (Arnaiz-Sánchez et al., 2023; Pov et al., 2024), contributing to the application of inequitable practices within

schools (López-Torrijo & Mengual-Andrés, 2015; Subban & Mahlo, 2016).

Previous research (AlMahdi & Bukamal, 2019; Braksiek, 2021; Ediyanto & Kawai, 2023; Ediyanto et al., 2020; Feila et al., 2019; Goddard & Evans, 2018; Hassanein et al., 2021; Issaka et al., 2022; Keka, 2024; Lautenbach & Heyder, 2019; Nishio et al., 2020; Puliatte et al., 2021; Qandhi & Kurniawati, 2018; Tuncay & Kizilaslan, 2022) has primarily discussed the attitudes of pre-service teachers towards inclusive education, the efficacy of inclusive education (Damayanti et al., 2022), and pre-service teachers' knowledge and perceptions of inclusive education (Mazzuki, 2024). There is a limited body of research exploring pre-service science teachers' understanding of inclusive learning design. To address this gap, the present study adopts three guiding frameworks: Technological Pedagogical and Content Knowledge (TPACK), Backward Design (BD) and Universal Design for Learning (UDL).

While previous studies have combined TPACK with UDL (Benton-Borghi, 2015, 2016; McCann, 2015; Suprihatiningrum, 2023) or BD (Mejia & Sargent, 2023), no research has fully integrated TPACK, BD and UDL to support inclusive learning design. The present study fills this gap by uniting these complementary frameworks. TPACK remains a widely used framework across diverse teacher populations, including pre-service teachers (Cheng, 2018; Deng et al., 2017; Jang & Chen, 2010; Scherer et al., 2018; Tondeur et al., 2017; Yurdakul, 2018), in-service teachers (Chen & Jang, 2019; Hsu et al., 2021; Hsu & Chen, 2018), online distance teachers (Archambault & Crippen, 2009; Joo et al., 2018; Obos et al., 2022) and teachers in professional development courses (Harris & Phillips, 2018; Koh et al., 2017). Its relevance endures, especially in dynamic cultural, policy and technological settings such as Indonesia, where it is commonly adopted in teacher education programmes (Koehler et al., 2014).

BD emphasises goal-oriented planning, encouraging teachers to begin with learning objectives and align assessments and instruction accordingly (McTighe & Thomas, 2003; Wiggins & McTighe, 2005). This approach fosters inclusive, student-centred learning that supports diverse needs, reduces stress and enhances curricular relevance (Childre et al., 2009; Cline et al., 2023; Maldonado, 2022). UDL provides a proactive framework for removing learning barriers by anticipating student variability from the outset, promoting accessibility and flexibility for all learners (CAST, 2018; Levey, 2021). It is grounded in three core principles: providing multiple means of representation, engagement and expression (Meyer et al., 2014). These principles encourage teachers to design curricula that present content in varied formats, motivate learners through diverse pathways, and allow students to demonstrate understanding in multiple ways (Rao et al., 2014; Rose et al., 2002). By doing so, UDL not only supports

learners with disabilities but also enhances equity for all students by recognising the full spectrum of learning preferences and needs (Meyer et al., 2014). Integrating these three frameworks offers a comprehensive foundation for preparing pre-service teachers to create inclusive, high-quality science instruction.

In the present study, each framework was mapped to the quantitative survey instrument and the qualitative interview protocol in order to operationalise the integration of TPACK, BD and UDL. This integrative lens enabled a comprehensive understanding of pre-service science teachers' inclusive design knowledge and provided triangulated insights across the cognitive, procedural and reflective dimensions of learning design. This integration not only serves as a framework for data collection and analysis but also as a model for future teacher education practices aimed at preparing teachers for inclusive classrooms. Therefore, the research will have a significant impact on future pre-service teachers. As student diversity increases, pre-service teachers need provisions that can be used to support and facilitate this diversity. In addition, teacher training universities can pay attention to curricula suitable for the needs of educational flux, so that the goals of Education for All and SDG 4 can be realised.

Research Problem

While inclusive education has been widely promoted in policy and theory, its practical implementation remains limited, particularly in the context of science education in Indonesia. Pre-service science teachers are often underprepared to apply inclusive pedagogical strategies, and existing teacher education programmes tend to marginalise inclusive education as an elective rather than an integral component. The present study addresses a critical gap in understanding how pre-service science teachers conceptualise and apply inclusive learning design, particularly through the integrated use of the TPACK, BD and UDL frameworks.

Research Questions

The study is guided by the following research questions:

1. What is the level of pre-service science teachers' knowledge of inclusive learning design based on the TPACK, BD and UDL frameworks?
2. Which aspects of TPACK, BD and UDL do pre-service teachers anticipate or experience as most challenging when considering or attempting to implement inclusive learning?

3. How does practical teaching experience shape the application of inclusive design principles in classroom practice?
4. To what extent does gender influence pre-service teachers' understanding of inclusive learning design?
5. To what extent does prior interaction with SEND students influence pre-service teachers' understanding of inclusive learning design?
6. How do pre-service teachers' perceptions of inclusive learning design align with their reported classroom practices and what factors explain discrepancies?

Method

Participants

A total of 263 university students agreed to participate in the survey, all of whom provided their informed consent through an online form. They were enrolled in pre-service teacher education programmes from eight universities in Indonesia, selected from both public and private institutions to ensure geographic and institutional diversity. The universities are UST, UNY, USD, UAD, UMS, UNNES, UM and UHO. The participants represented a mix of students from teacher education programmes at the elementary level. The sample included 71 male students and 192 female students. Of these students, 72 had teaching experience and 80 had interacted with students with SEND. The participants' demographics are presented in Table 1.

For the interview, 16 participants were selected using purposive sampling based on their survey responses, teaching experience and willingness to provide rich narratives. In the study, "teaching experience" refers to the participants' involvement in either microteaching sessions within their university coursework or short-term practicum/field teaching in schools as part of their teacher education programme. While some participants had already engaged in classroom practice through these structured activities, others had not yet had such opportunities. Consequently, the insights reported in the study may be drawn either from actual experiences in implementing inclusive practices or from anticipated challenges based on coursework and training activities.

Table 1
Participants' Demographics (N = 263)

Category		N	%
Gender	Male	71	27.00
	Female	192	73.00
Teaching experience	No	191	72.62
	Yes	72	27.38
Interaction with SEND student	Ever	80	30.42
	Never	183	69.58
University type	State	113	42.97
	Private	150	57.03

Data Collection Instruments

The study utilised two primary instruments: a self-report questionnaire and a semi-structured interview guide.

In order to assess the pre-service science teachers' knowledge of designing inclusive learning environments, a questionnaire developed by Suprihatin-ingrum et al. (2024) was used. The instrument consisted of 18 items distributed across eight dimensions, each corresponding to key constructs from the TPACK, BD and UDL frameworks. The items were rated on a 5-point Likert scale, capturing the participants' self-assessed knowledge of inclusive instructional design. The reliability of the instrument was confirmed through Cronbach's Alpha, with all subscales demonstrating strong internal consistency ($\alpha > 0.80$).

The interview protocol was structured to align with the three theoretical frameworks, probing how participants conceptualised and enacted inclusive learning.

Research Design

Mixed methods with a sequential exploratory design were used to explore the research phenomenon, involving several data sources and establishing the reliability and validity of the findings (Creswell, 2009). The quantitative phase involved distributing a survey to the participants, while the qualitative phase consisted of in-depth interviews to elaborate and deepen the understanding of the quantitative findings.

Survey Procedures and Demography of the Participants

Before the survey was conducted, the researchers sent letters to 26 universities registered as Pre-Service Education Programmes (PEP) for science across Indonesia. Eight universities expressed a willingness to participate in the survey. The researchers communicated with the head of the PEP and then sent an information letter, along with ethical clearance and approval letters, as a gatekeeper. The survey link, distributed via Google Forms, was shared by the head of the PEP through the participants' WhatsApp group, and the link remained open for two months.

Interview Procedures

Semi-structured interviews lasting 60–90 minutes were conducted either face-to-face (USD (Novi, Nadia), UNY (Ambar, Ida), UST (Tuti, Dewi), and UAD (Sari, Kiki)) or via phone calls (UMS (Hera, Manda), UM (Viji, Avia), UNNES (Ulfa, Laras), and UHO (Ema, Jeni)). All of the participants were female and have pseudonyms.

Data Analysis

Data from the survey were analysed using descriptive statistics to determine the level of knowledge, and independent sample t-tests were conducted to examine differences based on gender, teaching experience and prior interaction with students with SEND.

The interviews were audio-recorded, transcribed verbatim and analysed using thematic coding. This method was chosen for its adaptability and its ability to serve as a methodical framework for detecting, organising and evaluating thematic patterns within a comprehensive dataset, which makes it particularly applicable to educational qualitative research (Braun & Clarke, 2006). The coding process followed an inductive-deductive approach, with initial codes developed based on theoretical constructs and refined through an iterative reading process. Trustworthiness was enhanced through member checking, survey and interview data triangulation, and peer debriefing among research team members.

Results and Discussion

The findings from the quantitative and qualitative phases are discussed in relation to the five research questions and the integrated theoretical framework of TPACK, BD and UDL.

RQ1: What is the level of pre-service science teachers' knowledge of inclusive learning design based on the TPACK, BD and UDL frameworks?

Descriptive statistical analysis revealed that the pre-service science teachers surveyed demonstrated a high level of knowledge across all components of the integrated framework. The mean scores for all TPACK domains, including pedagogical (PK), content (CK) and technological knowledge (TK), as well as their intersections (TCK, PCK, TPK and TPACK), ranged from 3.49 to 3.91 (see Table 2). Inclusive Education Knowledge (IEK), which reflects UDL principles, also yielded a high mean score ($M = 3.75$).

Table 2
Descriptive Statistical Analysis

No	Aspects	Mean	SD	Category
1	PK	3.49	0.51	High
2	TK	3.91	0.62	High
3	CK	3.67	0.57	High
4	TCK	3.55	0.63	High
5	PCK	3.76	0.56	High
6	TPK	3.7	0.55	High
7	TPACK	3.63	0.57	High
8	IEK	3.75	0.56	High
	Total	3.68	0.47	High

These findings suggest a strong conceptual awareness of inclusive design that aligns with the expectations of the TPACK (knowledge integration), BD (design from learning goals) and UDL (multiple means of representation, engagement and expression) frameworks. Compared with previous research, the findings show a more positive knowledge baseline than studies conducted

in Western contexts, where pre-service teachers often report uncertainty in applying inclusive principles (e.g., Costello and Boyle (2013), Braksiek (2021)). However, studies by Benton-Borghi (2015, 2016) emphasise that conceptual understanding (especially of UDL-infused TPACK) is only the foundation and must be coupled with practice to be impactful.

In the Indonesian context, some studies (Ediyanto et al., 2020; Fitriana-sari & Budiyanto, 2015; Muzdalifah & Billah, 2017; Putri & Hamdan, 2021) have revealed that pre-service teachers show moderately positive attitudes towards inclusive education, but their pedagogical readiness remains limited. In the present study, nearly all of the pre-service teachers interviewed expressed positive attitudes towards SEND students. For instance, Ema (interview, 24 February 2024) stated:

In this training programme, I learned a lot about differentiated instruction. When we created lesson plans, our lecturer asked us to design using differentiated instruction. [...] Then, I realised that each student has unique characteristics. We, as prospective teachers, were required to design learning that accommodates the diversity of students, including those with disabilities. These children must be given equal education; we must not discriminate against them. However, it's hard to realise it.

Our findings extend this by showing that where positive attitudes exist, they may contribute to greater confidence in self-assessed knowledge, particularly when inclusive values are embedded in teacher preparation. This aligns with the claim of Sharma et al. (2003) that positive attitudes can enhance motivation and engagement with inclusive pedagogies, as well as with the findings of Tindall et al. (2015), who note that favourable dispositions support the uptake of inclusive instructional strategies. Conversely, Muzdalifah and Billah (2017) highlight the fact that a lack of pedagogical knowledge can hinder enacting even well-intentioned inclusive beliefs.

Thus, the relationship between knowledge and attitude is bidirectional: strong inclusive attitudes can encourage deeper learning of inclusive strategies, while pedagogical training may reinforce and shape attitudes through exposure to successful inclusive practices. Nevertheless, relying on self-report surveys means that these high scores may reflect perceived knowledge rather than enacted practice. As highlighted by Scherer et al. (2018) pedagogical, and content knowledge: Comparing structural equation modeling approaches

Computers in Human Behavior

Computers in Human Behavior

67-80

80

volume><dates><year>2018</year></dates><urls></urls><electronic-resource-num>10.1016/j.chb.2017.11.003</electronic-resource-num></record></Cite></EndNote>, TPACK confidence can be inflated in early-career teachers unless accompanied by field-based experiences. Therefore, while the knowledge levels are promising, they must be viewed as an entry point rather than an endpoint in developing inclusive pedagogical competence.

This pattern resonates with the findings of Lautenbach and Heyder (2019), who noted that inclusive attitudes tend to improve when supported by structured coursework. Similarly, Goddard and Evans (2018) observed that when inclusive pedagogy is explicitly modelled during teacher education, pre-service teachers show both greater confidence and competence in its application, suggesting that attitudes, knowledge and exposure to practice reinforce one another.

RQ2: Which aspects of TPACK, BD and UDL do pre-service teachers anticipate or experience as most challenging when considering or attempting to implement inclusive learning?

The interview data provided a better understanding of the implementation barriers. Although many of the pre-service science teachers self-reported a high level of knowledge in the survey, their interview responses revealed that several components of TPACK, BD and UDL remained difficult to apply in practice. Importantly, not all of the participants had engaged in actual classroom teaching; therefore, some of the challenges described should be interpreted as anticipated difficulties based on coursework or microteaching, while others stem from real experiences in practicum or field teaching. Clarifying this distinction helps contextualise the findings and prevents overgeneralisation of the reported barriers.

In the UDL framework, for example, some participants reported difficulties providing multiple means of expression and engagement. Kiki (interview, 25 February 2024) noted, “We were told to accommodate different learning needs, but I’m not sure how to let students express their understanding differently without making the assessment feel unequal”. This highlights a gap between UDL’s principle of flexibility and the participants’ readiness to design assessments beyond traditional formats.

Within the BD framework, challenges were identified in defining inclusive learning goals that align with assessment and instruction. Sari (interview, 21 February 2024) shared that she struggled to define learning goals that were measurable yet inclusive: “Sometimes we only think about completing the

syllabus without questioning if the objectives are relevant for all students”. This reflects a partial grasp of the backward design model, where end goals should drive instructional design. Similar issues were observed in other studies, such as that by Neiles and Arnett (2021), who emphasised that novice teachers often struggle to identify meaningful learning outcomes that address diverse needs.

On the TPACK side, while technological familiarity was high, the participants often used devices in non-inclusive ways. For instance, Ambar (interview, 26 February 2024) used digital quizzes regularly but admitted that “some students were left behind because they couldn’t use the devices fluently”. This example reveals an entry level of engagement with technology, lacking integration with pedagogy and content to support inclusive practices, which relates to the findings of Suprihatiningrum (2023) and McCann (2015), who note that without critical reflection, technological knowledge alone does not ensure inclusive teaching.

The findings of the present study align with those of McGhie-Richmond and Sung (2013), who observe that pre-service teachers understand UDL in theory but often fail to incorporate its principles meaningfully in practice. Spooner et al. (2007) similarly reported that pre-service teachers require intensive and structured training to apply UDL strategies effectively. Furthermore, Marino et al. (2009) emphasised that unless technology is used with an inclusive lens, it can widen gaps rather than bridge them. Finally, Ahsan et al. (2011) pointed out that inadequate curricula and lack of field experience remain systemic obstacles in teacher preparation for inclusive education.

While the participants in the present study possessed conceptual understanding, applying these frameworks in complex classroom settings exposed gaps in their pedagogical design capabilities. These gaps indicate the need for more practice-based coursework and modelling within teacher education programmes, particularly with regard to how inclusive strategies are planned, assessed and adjusted in real time.

RQ3: How does practical teaching experience shape the application of inclusive design principles in classroom practice?

An independent samples t-test was conducted to compare the mean scores across eight domains of teacher knowledge between the participants with teaching experience (“Yes”, $N = 71$) and those without (“No”, $N = 192$). The results revealed statistically significant differences in knowledge scores based on teaching experience ($p < 0.001$) (see Table 3). When interpreting these results, it is essential to clarify that “practical teaching experience” encompasses a range of exposures, including microteaching sessions, short-term practicums

and, in some cases, volunteer teaching. These experiences were not always formally structured or accompanied by guided reflection, which may have influenced how the participants articulated their application of inclusive principles. This contextual nuance is essential for understanding the validity of comparisons between those with and without experience.

The interviews confirmed that the participants with classroom experience articulated more integrated and contextually grounded applications of inclusive design. For instance, Viji (interview, 4 March 2024) emphasised how her lesson plans evolved when she observed students with SEND disengaging, prompting her to diversify content representation (UDL principle 1) and scaffold tasks (TPACK-PCK domain). She tended to reflect more critically on lesson effectiveness and made real-time pedagogical adjustments, demonstrating alignment with BD's reflective and goal-oriented approach.

Table 3

Independent Sample t-test on Teaching Experience

No	Aspect	Yes (N = 71)		No (N = 192)		Sig.2 tailed	
		M	SD	M	SD		
1	PK	3.79	0.50	3.63	0.51	0.019	H ₀ is rejected
2	TK	4.13	0.57	3.93	0.63	0.018	H ₀ is rejected
3	CK	4.02	0.60	3.80	0.56	0.004	H ₀ is rejected
4	TCK	3.93	0.59	3.60	0.63	0.000	H ₀ is rejected
5	PCK	4.03	0.56	3.82	0.56	0.008	H ₀ is rejected
6	TPK	4.13	0.51	3.77	0.54	0.000	H ₀ is rejected
7	TPACK	4.01	0.50	3.72	0.58	0.000	H ₀ is rejected
8	IEK	4.07	0.59	3.81	0.54	0.001	H ₀ is rejected
	Total	4.02	0.43	3.76	0.47	0.000	H ₀ is rejected

Other participants reinforced this trend. Manda (interview, 2 March 2024) stated, "At first, I just followed the lesson plan, but then I realised I had to change how I taught because one student did not understand verbal instructions well. I added visual aids and asked them to present with drawings". This shift shows not only the application of UDL (multiple means of expression and representation) but also indicates increased sensitivity to learner variability. Similarly, Hera (interview, 27 February 2024) mentioned how experience in microteaching classes allowed her to "trial different strategies and notice what works better for students who learn more slowly".

These narratives align with Oleson et al. (2018), who argue that hands-on teaching opportunities are crucial in developing adaptive expertise among novice teachers, especially in designing for learner variability. Likewise, Baron (2018) emphasises that ethical and inclusive curriculum design requires ongoing reflection, which is cultivated through real-world teaching. The presence of teaching experience also seems to sharpen the way participants in the present study link assessment with instructional goals, which is a fundamental aspect of Backward Design.

In the present study, the participants with experience also reported more comfort navigating the intersections of TPACK elements in inclusive settings. For example, Ambar (interview, 26 February 2024) shared that her use of multimedia tools improved after seeing how students responded differently to visual versus auditory materials. This supports findings by Archambault and Crippen (2009), who note that technological knowledge must be embedded in authentic practice to be meaningfully applied. This is further supported by Goddard and Evans (2018), who find that experience working with diverse learners allows pre-service teachers to adjust their expectations and diversify their teaching strategies.

Furthermore, Braksiek (2021) emphasised that inclusive teaching cannot be reduced to fixed methods, but is developed through active experimentation and reflective dialogue in practice settings. Similarly, Lautenbach and Heyder (2019) observed that sustained engagement in real classrooms builds teachers' confidence and responsiveness to student diversity. The findings of Navarro et al. (2016) also indicate that field-based exposure helps internalise inclusive values, bridging the gap between abstract frameworks and applied teaching decisions. In addition, a study by Florian and Beaton (2018) highlights the fact that inclusive pedagogy thrives when teachers engage in iterative design cycles rooted in actual classroom dynamics.

Therefore, practical experience not only enhances confidence but also helps translate theoretical understanding into pedagogical action. It is a critical site where TPACK, BD and UDL frameworks are tested, refined and embodied in practice.

RQ4: To what extent does gender influence pre-service teachers' understanding of inclusive learning design?

Quantitative analysis revealed no statistically significant differences ($p > 0.001$) in knowledge scores based on gender (see Table 4).

Table 4
Independent Sample t-test on Gender

No	Aspect	Male (N = 71)		Female (N = 192)		Sig.2 tailed	
		M	SD	M	SD		
1	PK	3.78	0.52	3.64	0.49	0.036	H ₀ is rejected
2	TK	4.12	0.65	3.94	0.6	0.035	H ₀ is rejected
3	CK	3.94	0.54	3.83	0.58	0.156	H ₀ is accepted
4	TCK	3.77	0.65	3.66	0.62	0.257	H ₀ is accepted
5	PCK	3.98	0.61	3.84	0.55	0.067	H ₀ is accepted
6	TPK	3.94	0.57	3.84	0.54	0.216	H ₀ is accepted
7	TPACK	3.88	0.61	3.77	0.55	0.194	H ₀ is accepted
8	IEK	3.95	0.58	3.85	0.56	0.214	H ₀ is accepted
	Total	3.92	0.49	3.79	0.45	0.06	H ₀ is accepted

The lack of a consistent gender effect can be interpreted through multiple lenses. Although some research (e.g., Ozudogru and Ozudogru (2019)) found gender-based differences in confidence or TPACK application, other studies (e.g., Raman (2014); Roig-Vila et al. (2015)) found no significant variance. In our study, it is possible that equal access to teacher education resources minimised gender disparity in pedagogical knowledge. Nevertheless, cultural expectations and implicit biases, which are rarely captured in quantitative measures, may still influence how inclusive design is perceived and enacted (Tindall et al., 2015). This suggests that while gender did not statistically shape inclusive knowledge in this sample, subtle gendered dynamics may still be present and warrant further exploration.

RQ5: To what extent does prior interaction with SEND students influence pre-service teachers' understanding of inclusive learning design?

Quantitative analysis also revealed no statistically significant differences ($p > 0.001$) in knowledge scores based on prior interaction with students with SEND (see Table 5).

Table 5*Independent Sample t-test on Interacting with Students with SEND*

No	Aspect	Ever (N = 80)		Never (N = 183)		Sig.2 tailed	
		M	SD	M	SD		
1	PK	3.61	0.49	3.70	0.52	0.186	H ₀ is accepted
2	TK	4.03	0.61	3.97	0.63	0.443	H ₀ is accepted
3	CK	3.87	0.52	3.86	0.60	0.912	H ₀ is accepted
4	TCK	3.66	0.59	3.71	0.66	0.570	H ₀ is accepted
5	PCK	3.79	0.54	3.92	0.58	0.100	H ₀ is accepted
6	TPK	3.77	0.56	3.91	0.54	0.055	H ₀ is accepted
7	TPACK	3.76	0.55	3.82	0.58	0.467	H ₀ is accepted
8	IEK	3.88	0.53	3.88	0.58	0.970	H ₀ is accepted
	Total	3.80	0.46	3.85	0.48	0.449	H ₀ is accepted

The interview data offer additional insight. Several of the participants acknowledged encountering SEND students, but these experiences were often superficial, unstructured or lacked intentional pedagogical guidance. For instance, Ulfa (interview, 27 February 2024), who had previously volunteered in an inclusive classroom, shared: “I had experience with a student with a hearing impairment, but no one really explained how to adapt materials. I just tried to be patient, but wasn’t confident about what I was doing”. Dewi (interview, 26 February 2024) admitted that while she had a student with hearing difficulties in her practicum, “no one guided me on how to adapt the lesson. It was up to me to figure it out”. Nadia (interview, 2 March 2024) reflected: “Maybe we interacted with SEND students, but without knowing what to look for or what adjustments to make, it didn’t become part of our knowledge”.

These accounts reinforce the idea that contact alone, without pedagogical framing or structured reflection, may not lead to meaningful shifts in understanding. This aligns with the findings of Ediyanto et al. (2020) and Avramidis and Norwich (2002), who argue that interaction alone does not guarantee a shift in knowledge or belief, but must be accompanied by reflection, modelling and institutional support. Likewise, Forlin et al. (2013) emphasise that the quality and structure of experiences with inclusive education matter more than their frequency. Florian and Rouse (2009) further argue that without structured pedagogical preparation, exposure to diverse learners may reinforce rather than challenge existing biases.

Additionally, research by AlMahdi and Bukamal (2019) highlights the

fact that even when pre-service teachers have positive attitudes towards inclusion, those attitudes are not always predictive of inclusive instructional competence unless coupled with experiential and structured practice. This suggests that identity factors like gender and interaction history must be supported by meaningful pedagogical training in order to translate into knowledge development.

RQ6: How do pre-service teachers' perceptions of inclusive learning design align with their reported classroom practices and what factors explain discrepancies?

The present study found a notable gap between the pre-service teachers' conceptual understanding of inclusive design and their ability to put it into practice. While many of the participants endorsed the importance of inclusive practices and demonstrated a high level of self-reported knowledge, the interviews revealed that emotional, cognitive and institutional factors limited the translation of these beliefs into practice. Avia (interview, 25 February 2024) admitted, "I believe in inclusion, but sometimes I just don't know how to support them [SEND students] effectively". This suggests a disconnect between theoretical commitment and pedagogical enactment.

The interview data further illustrated this gap. Ida (interview, 26 February 2024) reflected, "I always wrote in my lesson plan that learning should be inclusive, but when it came to group work, I often forgot to think about whether all students could participate equally". Similarly, Novi (interview, 2 March 2024) said, "We were taught inclusive education, but sometimes it felt like something separate from real science teaching, like a bonus, not a core". These statements emphasise how pre-service teachers may knowledgeably support inclusion but lack the confidence or strategies to integrate it into their daily instruction.

This finding echoes the argument of Florian and Black-Hawkins (2011) that inclusive pedagogy is not merely about intentions but the ability to make thoughtful instructional choices that respond to learner diversity. Pre-service teachers may default to traditional methods even when they value inclusivity without structured opportunities to rehearse and reflect on inclusive practices. This underscores the fact that the evidence presented here is qualitative and self-reported, meaning the identified discrepancies should be interpreted as indicative perceptions rather than empirically verified teaching behaviours.

Studies by Rouse (2008) and Sharma et al. (2003) emphasise the importance of modelling inclusive practices within teacher education itself. The participants in the present study noted that inclusive education was often treated

as an elective rather than integrated into core pedagogy courses, which may have weakened its perceived relevance. Goddard and Evans (2018) further suggest that discrepancies between belief and practice can be narrowed through explicit feedback, classroom-based coaching and guided inquiry.

The absence of assistive technologies, limited access to differentiated teaching materials and insufficient mentoring during practicums were recurring themes. These issues are consistent with the findings of Sokal and Sharma (2017), who state that system-level barriers can undermine even the most well-prepared teachers' efforts to apply inclusive design. In addition, research by Ainscow and Sandill (2010) highlights the fact that inclusion must be understood as a continuous school transformation process, not just an individual teacher's effort. Therefore, systemic and institutional support is crucial in order to bridge the gap between what pre-service teachers know and what they can implement. While pre-service teachers usually support the concept of inclusive education, the implementation remains limited because of an intersection of personal, institutional and systematic obstacles, suggesting an apparent misalignment between perception and practice.

Conclusions

The findings of the present study reveal that while pre-service teachers conceptually value inclusive practices, many of them still face challenges in applying these principles, particularly in differentiating instruction, aligning assessments with learning goals and integrating inclusive technologies. A key outcome is the identification of teaching experience as a significant factor influencing the application of practical knowledge. However, the study also finds that neither gender nor prior interaction with SEND students significantly affects inclusive design knowledge, suggesting that experiential learning opportunities must be purposefully structured and pedagogically scaffolded. The study implies that inclusive education should be integrated across all aspects of teacher preparation, rather than being treated as a supplemental theme. Teacher education programmes must provide practice-based learning that integrates inclusive frameworks into real-world contexts.

The study has several limitations. The reliance on self-reported data may expand perceptions of competence, and the sample is limited to Indonesian pre-service teachers, which may affect the generalisability of the findings. Furthermore, while the integration of TPACK, BD and UDL provides a strong theoretical model, the study did not quantitatively measure the interaction effects between these frameworks. Future research should explore longitudinal studies

tracking pre-service teachers into their early careers to examine how inclusive knowledge evolves with practice. Comparative studies across countries or cultural contexts may also reveal how systemic factors influence the implementation of inclusive pedagogy. Additionally, investigating the impact of specific interventions (e.g., inclusive microteaching, assistive tech workshops) on inclusive design competence would yield practical insights for teacher education reform. In practice, the present study supports the call for a reconfiguration of teacher preparation in Indonesia and similar contexts, one that moves beyond policy rhetoric towards intentional, integrated and experiential pathways to inclusive teaching.

Ethical statement

The present study was conducted according to ethical guidelines for educational research involving human participants. Ethical approval was obtained from the Ethics Committee of UIN Sunan Kalijaga Yogyakarta with reference number B-3315.25/Un.02/L3/TL/07/2022. All of the participants were informed about the purpose of the research, and informed consent was obtained prior to data collection. Participation was voluntary, and confidentiality and anonymity were maintained throughout the study.

Disclosure statement

The authors declare no conflicts of interest.

References

- Ahsan, M. T., Sharma, U., & Deppeler, J. M. (2011). Challenges to prepare pre-service teachers for inclusive education in Bangladesh: Beliefs of higher educational institutional heads. *Asia Pacific Journal of Education*, 32(2), 241–257.
- Ainscow, M. (2020). Promoting inclusion and equity in education: Lessons from international experiences. *Nordic Journal of Studies in Educational Policy*, 6(1), 7–16.
<https://doi.org/10.1080/20020317.2020.1729587>
- Ainscow, M., & Sandill, A. (2010). Developing inclusive education systems: The role of organisational cultures and leadership. *International Journal of Inclusive Education*, 14(4), 401–416.
<https://doi.org/10.1080/13603110802504903>
- AlMahdi, O., & Bukamal, H. (2019). Pre-Service Teachers' Attitudes Toward Inclusive Education During Their Studies in Bahrain Teachers College. *Sage Open*, 9(3).
<https://doi.org/10.1177/2158244019865772>

- Archambault, L., & Crippen, K. (2009). Examining TPACK among K-12 online distance educators in the United States. *Contemporary Issues in Technology and Teacher Education*, 9(1), 71–88. <https://citejournal.org/volume-9/issue-1-09/general/examining-tpack-among-k-12-online-distance-educators-in-the-united-states>
- Arnaiz-Sánchez, P., De Haro-Rodríguez, R., Caballero, C. M., & Martínez-Abellán, R. (2023). Barriers to educational inclusion in initial teacher training. *Societies*, 13(2), 31. <https://doi.org/10.3390/soc13020031>
- Avramidis, E., & Norwich, B. (2002). Teachers' attitudes towards integration/inclusion: A review of the literature. *European Journal of Special Needs Education*, 17(2), 129–147.
- Baron, P., R. (2018). Ethical inclusive curricula design: Conversational teaching and learning. *South African Journal of Higher Education*, 32(6), 326–350. <https://doi.org/10.20853/32-6-2987>
- Benton-Borghi, B. H. (2015). Intersection and impact of Universal Design for Learning (UDL) and Technological, Pedagogical, and Content Knowledge (TPACK) on twenty-first century teacher preparation: UDL-infused TPACK practitioner's model. In C. Angeli, & N. Valanides (Eds.), *Technological Pedagogical Content Knowledge* (Vol. 48, pp. 287–304). Springer. https://doi.org/10.1007/978-1-4899-8080-9_15
- Benton-Borghi, B. H. (2016). Universal Design for Learning (UDL) infused Technological Pedagogical Content Knowledge (TPACK) model prepares efficacious 21st-century teachers. In M. J. Koehler, & P. Mishra (Eds.), *Handbook of Technological Pedagogical Content Knowledge (TPACK) for Educators*. Routledge. <https://doi.org/10.4324/9781315771328>
- Braksiek, M. (2021). Pre-service physical education teachers' attitudes toward inclusive physical education. *German Journal of Exercise and Sport Research*, 52(1), 1–10. <https://doi.org/10.1007/s12662-021-00755-1>
- CAST. (2018). *The Universal Design for Learning Guidelines Version 2.2. 2018–2018*. <https://udlguidelines.cast.org/>
- Chen, Y.-H., & Jang, S.-J. (2019). Exploring the relationship between self-regulation and TPACK of Taiwanese secondary in-service teachers. *Journal of Educational Computing Research*, 57(4), 978–1002. <https://doi.org/10.1177/0735633118769442>
- Cheng, H.-J. (2018). A TL-TPACK model on CSL pre-service teachers' competencies of online instruction. In H.-J. Cheng (Ed.), *Teacher Training and Professional Development: Concepts, Methodologies, Tools, and Applications* (pp. 280–308). IGI Global. <https://doi.org/10.4018/978-1-5225-5631-2.ch013>
- Childre, A., Sands, J. R., & Pope, S. T. (2009). Backward Design: Targeting depth of understanding for all learners. *TEACHING Exceptional Children*, 41(5), 6–14. <https://doi.org/10.1177/004005990904100501>
- Cline, K. M., Winhoven, M. M., Williams, V. L., Kelley, K. A., & Porter, B. L. (2023). Backward design to combat curricular expansion in a large, interdisciplinary, team-taught course. *American Journal of Pharmaceutical Education*, 87(9), 100052. <https://doi.org/10.1016/j.ajpe.2022.12.009>
- Costello, S., & Boyle, C. (2013). Pre-service secondary teachers' attitudes towards inclusive education.

- Australian Journal of Teacher Education*, 38(4), 129–143. <https://doi.org/10.14221/ajte.2013v38n4.8>
- Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd ed.). Sage Publications.
- Damayanti, A., Lintangari, A. P., & Kusumawardani, I. N. (2022). Teachers' efficacy in inclusive teaching: A study on EFL pre-service teachers. *Indonesian Journal of Disability Studies*, 9(2), 253–263. <https://doi.org/10.21776/ub.ijds.2022.009.02.09>
- Deng, F., Chai, C. S., So, H. J., Qian, Y., & Chen, L. (2017). Examining the validity of the technological pedagogical content knowledge (TPACK) framework for pre-service chemistry teachers. *Australasian Journal of Educational Technology*, 33(3). <https://doi.org/10.14742/ajet.3508>
- Ediyanto, & Kawai, N. (2023). The measurement of teachers' attitudes toward inclusive education: An empirical study in East Java, Indonesia. *Cogent Education*, 10(2), 1–13. <https://doi.org/10.1080/2331186x.2023.2229014>
- Ediyanto, Maulida, R., Atika, I. N., & Kawai, N. (2020). The pre-service teachers' attitudes towards inclusive education: An empirical study in Yogyakarta City, Indonesia. *Discourse and Communication for Sustainable Education*, 11(1), 65–73. <https://doi.org/10.2478/dcse-2020-0007>
- Eklund, G., Sundqvist, C., Lindell, M., & Toppinen, H. (2020). A study of Finnish primary school teachers' experiences of their role and competences by implementing the three-tiered support. *European Journal of Special Needs Education*, 36(5), 729–742. <https://doi.org/10.1080/08856257.2020.1790885>
- Feila, T. A., Ferrarob, C. A., & Feilc, M. R. (2019). Preservice teachers' attitudes toward inclusive education before and after student teaching. *Journal of Education & Social Policy*, 6(3), 8–13. <https://doi.org/10.30845/jesp.v6n3p2>
- Fitrianasari, H., & Budiyanto. (2015). Persepsi guru terhadap penyelenggaraan pendidikan inklusif sesuai latar pendidikan di Kabupaten Blitar [Teachers' perceptions of the implementation of inclusive education based on educational background in Blitar Regency]. *Jurnal Pendidikan Khusus*, 7(2).
- Florian, L., & Beaton, M. (2018). Inclusive pedagogy in action: Getting it right for every child. *International Journal of Inclusive Education*, 22(8), 870–884.
- Florian, L., & Black-Hawkins, K. (2011). Exploring inclusive pedagogy. *British Educational Research Journal*, 37(5), 813–828. <http://www.jstor.org/stable/23077052>
- Florian, L., & Rouse, M. (2009). The inclusive practice project in Scotland: Teacher education for inclusive education. *Teaching and Teacher Education*, 25(4), 594–601.
- Forlin, C., Chambers, D., Loreman, T., Deppeler, J., & Sharma, U. (2013). *Inclusive education for students with disability: A review of the best evidence in relation to theory and practice* (Report to the Australian Government Department of Foreign Affairs & Trade and Australian Research Alliance for Children and Youth, Canberra). ARACY.
- Goddard, C., & Evans, D. (2018). Primary pre-service teachers' attitudes towards inclusion across the training years. *Australian Journal of Teacher Education*, 43(6), 122–142. <https://doi.org/10.14221/ajte.2018v43n6.8>
- Harris, J. & Phillips, M. (2018). If There's TPACK, is There Technological Pedagogical Reasoning and

Action? In E. Langran & J. Borup (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 2051–2061). Association for the Advancement of Computing in Education (AACE). Retrieved November 3, 2025, from:

<https://www.learntechlib.org/primary/p/182811/>

Hassanein, E. E. A., Alshaboul, Y. M., & Ibrahim, S. (2021). The impact of teacher preparation on preservice teachers' attitudes toward inclusive education in Qatar. *Heliyon*, 7(9), Article e07925.

<https://doi.org/10.1016/j.heliyon.2021.e07925>

Hattie, J. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*.

Routledge.

Hsu, C.-Y., Liang, J.-C., Chuang, T.-Y., Chai, C. S., & Tsai, C. C. (2021). Probing in-service elementary school teachers' perceptions of TPACK for games, attitudes towards games, and actual teaching usage: A study of their structural models and teaching experiences. *Educational Studies*, 47(6), 734–750.

<https://doi.org/10.1080/03055698.2020.1729099>

Hsu, L., & Chen, Y.-J. (2018). Teachers' knowledge and competence in the digital age: Descriptive research within the TPACK framework. *International Journal of Information and Education Technology*, 8(6), 455–458. <https://doi.org/10.18178/ijiet.2018.8.6.1081>

Issaka, C. A., Nyaaba, M., & Iddrisu, F. A. (2022). Attitudes and concerns of pre-service teachers' about inclusive education enshrined in the new four-year basic education curriculum in Ghana.

European Journal of Education and Pedagogy, 3(1), 89–94. <https://doi.org/10.24018/ejedu.2022.3.1.239>

Jang, S.-J., & Chen, K.-C. (2010). From PCK to TPACK: Developing a transformative model for pre-service science teachers. *Journal of Science Education and Technology*, 19(6), 553–564.

<https://doi.org/10.1007/s10956-010-9222-y>

Joo, Y. J., Park, S., & Lim, E. (2018). Factors influencing preservice teachers' intention to use technology: TPACK, teacher self-efficacy, and technology acceptance model. *Journal of Educational Technology & Society*, 21(3), 48–59. <https://www.jstor.org/stable/26458506>

Keka, A. (2024). Primary school teachers' attitudes, perceptions and self-efficacy regarding students with special educational needs: A comparative study of the education systems in Slovenia and Kosovo. *Center for Educational Policy Studies Journal*, Article 1591. <https://doi.org/10.26529/cepsj.1591>

Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham, C. R. (2014). The Technological Pedagogical Content Knowledge framework. In J. Spector, M. Merrill, J. Elen, & M. Bishop (Eds.), *Handbook of Research on Educational Communications and Technology* (pp. 101–111). Springer.

https://doi.org/10.1007/978-1-4614-3185-5_9

Koh, J. H. L., Chai, C. S., & Lim, W. Y. (2017). Teacher professional development for TPACK-21CL: Effects on teacher ICT integration and student outcomes. *Journal of Educational Computing Research*, 55(2), 172–196. <https://doi.org/10.1177/0735633116656848>

Lautenbach, F., & Heyder, A. (2019). Changing attitudes to inclusion in preservice teacher education: A systematic review. *Educational Research*, 61(2), 231–253.

<https://doi.org/10.1080/00131881.2019.1596035>

Levey, S. (2021). Universal Design for Learning. *Journal of Education*, 203(2), 479–487.

<https://doi.org/10.1177/00220574211031954>

López-Torrijo, M., & Mengual-Andrés, S. (2015). An attack on inclusive education in secondary education. Limitations in initial teacher training in Spain. *Journal of New Approaches in Educational Research*, 4(1), 9–17. <https://doi.org/10.7821/naer.2015.1.100>

Maldonado, S. (2022). Moving forward in nursing education using the backward design. *Journal of Education*, 203(4), 925–930. <https://doi.org/10.1177/00220574211070220>

Mamlok-Naaman, R. (2024). Diversity and inclusion in science education: Why? A literature review. *Center for Educational Policy Studies Journal*, 14(1), 13–31. <https://doi.org/10.26529/cepsj.1718>

Marino, M. T., Sameshima, P., & Beecher, C. C. (2009). Enhancing TPACK with Universal Design for Learning to individualize learning. In P. Mishra, & M. J. Koehler (Eds.), *Handbook of Technological Pedagogical Content Knowledge (TPACK) for educators* (pp. 245–263). Routledge.

Massouti, A. (2021). Pre-service teachers' perspectives on their preparation for inclusive teaching: Implications for organizational change in teacher education. *The Canadian Journal for the Scholarship of Teaching and Learning*, 12(1). <https://doi.org/10.5206/cjsotl-rcacea.2021.1.10611>

Mazzuki, B. D. (2024). Preparing teachers for inclusive education: Pre-service teachers' knowledge, perceptions and experiences of inclusive pedagogy from teaching practice. *Center for Educational Policy Studies Journal*, Article 1807. <https://doi.org/10.26529/cepsj.1807>

McCann, K. H. (2015). *Using Technological, Pedagogical, and Content Knowledge (TPACK) to support Universal Design for Learning (UDL): A case study* [Doctoral dissertation, University of Hawai'i at Mānoa]. ScholarSpace. <http://hdl.handle.net/10125/50998>

McGhie-Richmond, D., & Sung, A. N. (2013). Applying Universal Design for Learning to instructional planning: Evidence from the field. *Learning Disability Quarterly*, 36(4), 195–208.

McTighe, J., & Thomas, R. S. (2003). Backward design for forward action. *Educational Leadership*, 60(5), 52–55.

Mejia, M., & Sargent, J. M. (2023). Leveraging technology to develop students' critical thinking skills. *Journal of Educational Technology Systems*, 51(4), 393–418. <https://doi.org/10.1177/00472395231166>

Meyer, A., Rose, D. H., & Gordon, D. (2014). *Universal Design for Learning: Theory and practice*. CAST Professional Publishing.

Ministry of Education and Culture of Indonesia. (2022). *Arah kebijakan PPG Prajabatan 2022* [Pre-service teacher training education 2022 policy direction].

<https://ppg.kemdikbud.go.id/prajab/detail-program-kurikulum>

Muzdalifah, F., & Billah, H. Z. (2017). Pengaruh efikasi pada sikap guru terhadap pendidikan inklusif [The influence of efficacy on teachers' attitudes toward inclusive education]. *Jurnal Penelitian dan Pengukuran Psikologi*, 6(1), 26–34. <https://doi.org/10.21009/jppp.061.06>

Navarro, S. M. B., Zervas, P., Gesa, R. F., & Sampson, D., G. (2016). Developing teachers' competences for designing inclusive learning experiences. *Educational Technology & Society*, 19(1), 17–27. <https://www.jstor.org/stable/jeductechsoci.19.1.17>

Neiles, K. Y., & Arnett, K. (2021). Backward design of chemistry laboratories: A primer. *Journal of Chemical Education*, 98(9), 2829–2839. <https://doi.org/10.1021/acs.jchemed.1c00443>

- Nijkawska, J. (2022). Inclusive teaching practices with learners with dyslexia: Face-to-face training-induced changes in foreign language teachers' self-efficacy beliefs, concerns and attitudes. *Center for Educational Policy Studies Journal*, 12(4), 129–154. <https://doi.org/10.26529/cepsj.1424>
- Nishio, A., Chano, J., Suzuki, Y., & Iketani, N. (2020). Comparing pre-service teachers' attitudes toward inclusive education in Thailand and Japan. *Creative Education*, 11(10), 2096–2105. <https://doi.org/10.4236/ce.2020.1110152>
- Obos, A. I., Aridah, A., & Rusmawaty, D. (2022). Transition to online learning: Implementing the TPACK framework by English teachers due to the COVID-19 pandemic. *Journal of Education and Teaching*, 4(1), 20–34. <https://doi.org/10.51454/jet.v4i1.199>
- Oleson, A., Mendez, C., Steine-Hanson, Z., Hilderbrand, C., Perdriau, C., Burnett, M., & Ko, A., J. (2018). Pedagogical content knowledge for teaching inclusive design. In L. Malmi, A. Korhonen, R. McCartney, & A. Petersen (Eds.), *Proceedings of the 2018 ACM Conference on International Computing Education Research (ICER '18)* (pp. 69–77). Association for Computing Machinery. <https://doi.org/10.1145/3230977.3230998>
- Ozudogru, M., & Ozudogru, F. (2019). Technological pedagogical content knowledge of mathematics teachers and the effect of demographic variables. *Contemporary Educational Technology*, 10(1), 1–24. <https://doi.org/10.30935/cet.512515>
- Pov, S., Kawai, N., & Nov, S. (2024). Preparing pre-service teachers to work in Cambodian inclusive classrooms: Knowledge, experience, and attitudes toward inclusion. *Teaching and Teacher Education*, 137, Article 104402. <https://doi.org/https://doi.org/10.1016/j.tate.2023.104402>
- Puliatte, A., Martin, M., & Bostedor, E. (2021). Examining preservice teacher attitudes and efficacy about inclusive education. *SRATE Journal*, 30(1), 1–10. https://www.srate.org/JournalEditions/Volume30-1/PDF/Puliatte_Examining_Preservice.pdf
- Putri, Y., & Hamdan, S. R. (2021). Sikap dan kompetensi guru pada pendidikan inklusi di sekolah dasar [Teachers' attitudes and competencies in inclusive education at elementary schools]. *Jurnal Pendidikan Inklusi*, 4(2), 146–160. <https://doi.org/10.26740/inklusi.v4n2.p138-152>
- Qandhi, F. F., & Kurniawati, F. (2018). Pre-service teachers' attitudes toward inclusive education. In D. R. Bintari, S. R. R. Pudjiati, S. R. Asih, S. Y. Indrasari, D. C. Pelupessy, F. Fausiah, D. E. Purba, & B. Takwin (Eds.), *Proceedings of the 2nd International Conference on Intervention and Applied Psychology (ICIAP 2018)* (pp. 588–601). Atlantis Press.
- Raman, A. (2014). TPACK confidence of pre-service teachers in Universiti Utara Malaysia. *Mediterranean Journal of Social Sciences*, 5(22), 167–175. <https://doi.org/10.5901/mjss.2014.v5n22p167>
- Rao, K., Ok, M. W., & Bryant, B. R. (2014). A review of research on universal design educational models. *Remedial and Special Education*, 35(3), 153–166. <https://doi.org/10.1177/0741932513518980>
- Roig-Vila, R., Mengual-Andrés, S., & Quinto-Medrano, P. (2015). Primary teachers' technological, pedagogical and content knowledge. *Comunicar*, 23(45), 151–159. <https://doi.org/10.3916/C45-2015-16>
- Rose, D. H., Meyer, A., Strangman, N., & Rappolt, G. (2002). *Teaching every student in the digital age: Universal design for learning*. Association for Supervision and Curriculum Development (ASCD).
- Rouse, M. (2008). Developing inclusive practice: A role for teachers and teacher education? *Educa-*

- tion in the North, 16(1), 1–20. <https://www.abdn.ac.uk/education/research/eitn/journal/46/>
- Rubie-Davies, C. M. (2010). Teacher expectations and perceptions of student attributes: Is there a relationship? *British Journal of Educational Psychology*, 80(Pt 1), 121–135. <https://doi.org/10.1348/000709909X466334>
- Sanger, C. S. (2020). Inclusive Pedagogy and Universal Design Approaches for Diverse Learning Environments. In C. S. Sanger & N. W. Gleason (Eds.), *Diversity and Inclusion in Global Higher Education: Lessons from Across Asia* (pp. 31–71). Springer Singapore. https://doi.org/10.1007/978-981-15-1628-3_2
- Scherer, R., Tondeur, J., Siddiq, F., & Baran, E. (2018). The importance of attitudes toward technology for pre-service teachers' technological, pedagogical, and content knowledge: Comparing structural equation modeling approaches. *Computers in Human Behavior*, 80, 67–80. <https://doi.org/10.1016/j.chb.2017.11.003>
- Sharma, U., Ee, J., & Desai, I. (2003). A comparison of Australian and Singaporean pre-service teachers' attitudes and concerns about inclusive education. *Teaching and Learning*, 24(2), 207–217.
- Shevchenko, Y. M., Dubiaha, S. M., Melash, V. D., Fefilova, T. V., & Saenko, Y. O. (2020). The role of teachers in the organization of inclusive education of primary school pupils. *International Journal of Higher Education*, 9(7). <https://doi.org/10.5430/ijhe.v9n7p207>
- Sokal, L., & Sharma, U. (2017). Do I really belong here? Using a model of social cognitive career theory to explore perceptions of belonging, preservice teachers' efficacy, and career commitment in inclusive education. *Teaching and Teacher Education*, 66, 10–20.
- Spooner, F., Baker, J. N., Harris, A. A., Ahlgrim-Delzell, L., & Browder, D. M. (2007). Effects of training in Universal Design for Learning on lesson plan development. *Remedial and Special Education*, 28(2), 108–116.
- Subban, P., & Mahlo, D. (2016). 'My attitude, my responsibility' investigating the attitudes and intentions of pre-service teachers toward inclusive education between teacher preparation cohorts in Melbourne and Pretoria. *International Journal of Inclusive Education*, 21(4), 441–461. <https://doi.org/10.1080/13603116.2016.1197322>
- Suprihatiningrum, J. (2023). TPACK – UDL Scale for science teachers: Construction, validation, and reliability. *Randwick International of Education and Linguistics Science Journal*, 4(2), 339–354. <https://doi.org/10.47175/rielsj.v4i2.648>
- Suprihatiningrum, J., Palmer, C., & Aldous, C. (2022). The orthodoxy of special education among public, private, and Islamic secondary schools providing inclusive education. *Jurnal Pendidikan Agama Islam*, 19(1), 55–68. <https://doi.org/10.14421/jpai.2022.191-05>
- Suprihatiningrum, J., Wijayanti, A., Salam, F. W., & Hidayah, M. A. (2024). Scale for pre-service science teachers' knowledge in designing inclusive learning: Construction, validation, and reliability. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, 8(2), 577–592. <https://doi.org/10.22437/jiituj.v8i2.33958>
- Tindall, D., MacDonald, W., Carroll, E., & Moody, B. (2015). Pre-service teachers' attitudes towards children with disabilities: An Irish perspective. *European Physical Education Review*, 21(2), 206–221. <https://doi.org/10.1177/1356336X14556861>

- Tondeur, J., Scherer, R., Siddiq, F., & Baran, E. (2017). A comprehensive investigation of TPACK within pre-service teachers' ICT profiles: Mind the gap! *Australasian Journal of Educational Technology*, 33(3), 46-60. <https://doi.org/10.14742/ajet.3504>
- Tuncay, A. A., & Kizilaslan, A. (2022). Pre-service teachers' sentiments, attitudes and concerns about inclusive education in Turkey [Article]. *European Journal of Special Needs Education*, 37(2), 309-322. <https://doi.org/10.1080/08856257.2021.1873524>
- Wang, R.-J., & Shih, Y.-H. (2022). Improving the quality of teacher education for sustainable development of Taiwan's education system: A systematic review on the research issues of teacher education after the implementation of 12-year national basic education. *Frontiers in Psychology*, 13(921839), 1-12. <https://doi.org/10.3389/fpsyg.2022.921839>
- Wiggins, G., & McTighe, J. (2005). *Understanding by Design* (2nd ed.). ASCD.
- Yurdakul, I. K. (2018). Modeling the relationship between pre-service teachers' TPACK and digital nativity. *Educational Technology Research and Development*, 66, 267-281. <https://doi.org/10.1007/s11423-017-9546-x>

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