



Pedagogical Anxiety Among Pre-Service Biology Teachers During Teaching Practicum on Teaching Internship Program: A Needs Analysis for TPACK- and Self-Efficacy-Based E-Module Development

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Article Info	Abstract
Keywords: <i>pedagogical anxiety;</i> <i>pre-service teacher;</i> <i>teaching practicum;</i> <i>biology teaching; TPACK;</i> <i>self-efficacy; needs</i> <i>analysis</i> Received: 11/04/2026 Revised: 15/05/2026 Accepted: 25/05/2026	Pedagogical anxiety is a prevalent yet underaddressed challenge among pre-service biology teachers during teaching practicum. While anxiety during field experiences is widely recognized, targeted diagnostic studies that directly inform instructional resource development remain limited, particularly in the Indonesian biology teacher education context. This study aimed to analyze the profile of biology pedagogical anxiety among pre-service teachers during the Teaching Internship Program as a needs analysis foundation for developing a TPACK- and self-efficacy-based e-module. A descriptive survey design was employed, with data collected from pre-service biology teachers using a validated biology pedagogical anxiety instrument organized across four dimensions: Low Self-Confidence in Biology Ability, Fear of Failing to Understand Biology Concepts, Negative Attitude toward Biology, and General Fear of the Subject. Mean scores were categorized using an equal-interval four-level scale (Low, Moderate, High, Very High). Results revealed that 56% of respondents registered in the mild-to-marked or severe anxiety and extreme anxiety categories, with 9% reporting extreme anxiety levels, indicating that for a substantial proportion of student-teachers, the internship constitutes a significantly high-stress professional experience. The overall mean score of 2.59 placed the cohort in the High category. At the dimensional level, General Fear of the Subject ($M = 3.08$, High) and Fear of Failing to Understand Biology Concepts ($M = 2.55$, High) emerged as the dominant anxiety drivers, while Low Self-Confidence ($M = 2.35$) and Negative Attitude toward Biology ($M = 2.40$) fell in the Moderate range, suggesting that anxiety stems primarily from instructional uncertainty and content-mastery gaps rather than subject disengagement. These findings provide a clear empirical basis for developing a TPACK- and self-efficacy-based e-module targeting the specific pedagogical preparation needs of pre-service biology teachers, and contribute a replicable needs analysis model for evidence-based educational resource development.

INTRODUCTION

The teaching practicum under the teaching internship program is an important agenda organized at the later stage of a teacher education program that gives pre-service teachers a real-life test of their teaching competence (Huu Nghia & Tai, 2019). Rather than functioning as a merely procedural requirement, the internship phase exposes pre-service teachers to the complexity of school culture, mentor expectations, and pupils' diverse needs. Thus, this phase serves as a powerful context in which theoretical knowledge, professional identity, and emotional resilience are tested simultaneously.

For pre-service biology teachers, this transition is uniquely demanding because biology instruction requires simultaneous command of conceptually dense and often abstract content knowledge, such as microscopic structures and dynamic systems, alongside the use of pedagogical strategies that can make these ideas visible and meaningful to learners. Recent Indonesian studies on biology teachers' Technological Pedagogical Content Knowledge (TPACK) show that while content and basic pedagogical knowledge tend to be rated relatively high, technological knowledge and integrated TPACK dimensions (TCK, TPK, TPACK) are frequently only at moderate levels, indicating that many biology teachers feel less confident when they must integrate content, pedagogy, and technology in real classrooms (Aina et al., 2025; Marlina et al., 2023; Pradana et al., 2025; Tobing et al., 2024).

Against this background, anxiety during teaching internships is not an exceptional reaction but a frequent and well-documented response among pre-service teachers. Research across contexts has shown that teaching-related anxiety during practicum is associated with concerns about lesson preparation, classroom management, fear of negative evaluation, and perceived lack of teaching experience, and can significantly undermine teaching self-efficacy and instructional performance (Gorospe, 2022; Turgay & Tuglar, 2019). In Indonesia, most of this work has focused on EFL pre-service teachers, who report moderate to high anxiety levels arising from the pressure to use the target language, manage unpredictable student responses, and meet mentor expectations during school-based teaching practice (Salsabila & Zaki, 2024; Adinda, 2024), while science-education research suggests that anxiety associated with teaching science is intertwined with attitudes, locus of control, and self-efficacy (Senler, 2016).

However, within this growing literature, subject-specific pedagogical anxiety in biology, particularly in the context of teaching internships, remains underexplored in Indonesia. Existing anxiety studies tend to conceptualise teaching anxiety in general terms or focus on language education, whereas biology education research has largely examined TPACK profiles, teaching practices, and learning environments without explicitly theorising or measuring biology pedagogical anxiety (Sastria, 2023; Aina et al., 2025; Pradana et al., 2025). At the same time, international work on science teaching anxiety has only recently begun to clarify how anxiety related to teaching science links to interest and self-efficacy, and it typically treats "science" as a broad domain rather than distinguishing biology as a discipline with its own conceptual and representational challenges.

A preliminary study was conducted through interviews with a small sample of pre-service biology teachers who had experienced teaching internships in order to identify the main sources of difficulty during teaching practice. The most common issues are difficulty in adjusting the teaching schedule due to limited teaching time and inadequate teaching evaluations from supervising teacher. Some research on pre-service teachers' internship experiences found that mismatches between teacher education preparation and the realities of school placement can create practical difficulties that make the internship experience less effective (Rahayuningsih, 2016; Huu Nghia & Tai, 2019; Aldabbus, 2020; Faisal et al., 2025).

Two interrelated theoretical constructs guide the way this study defines biology pedagogical anxiety. Drawing first on Bandura's (1997) self-efficacy theory, teaching self-efficacy is understood as a key determinant of anxiety, such that low beliefs about one's capability to organise and execute teaching tasks amplify anxiety and can erode instructional quality; this relationship is supported by evidence that pre-service science teachers' academic self-efficacy toward biology is positively related to motivation and engagement (Ates & Saylan, 2015). Complementing this, Mishra & Koehler's (2006) Technological Pedagogical Content Knowledge (TPACK) framework building on Shulman's (1987) notion of Pedagogical Content Knowledge, emphasises that effective biology teaching in contemporary classrooms depends on the integration of content, pedagogy, and technology, and recent Indonesian work has started to operationalise this integration for pre-service biology teachers through TPACK instruments and profiling studies. Within this perspective, deficiencies in any component of this integrated knowledge base, especially in using technology to represent abstract biological phenomena, are expected to manifest as anxiety when pre-service biology teachers plan and deliver lessons during their teaching internship.

Despite growing recognition of the importance of both teaching self-efficacy and TPACK-based competence, structured learning support tools that explicitly integrated TPACK and teaching self-efficacy remain notably scarce in the Indonesian teacher-education landscape. Existing studies either map anxiety levels and their sources during practicum or describe the distribution of TPACK components among pre-service biology teachers, but they rarely translate these findings into concrete, digital learning supports tailored to the internship phase (Gorospe, 2022; Tobing et al., 2024). Drawing on the conceptualisation of subject-specific pedagogical anxiety introduced in mathematics education (Pahmi et al., 2025), this study therefore adapts the notion to biology and positions biology pedagogical anxiety as the perceived anxiety pre-service teachers experience specifically when planning and delivering biology instruction during their teaching internship. In line with this aim, the present research constitutes the needs-analysis stage of a broader Research and Development (R&D) project that seeks (1) to describe the pedagogical anxiety profile among pre-service biology teachers who have completed their teaching internship, and (2) to use these findings to empirically justify and inform the content priorities of a TPACK- and self-efficacy-based e-module to support future biology teaching internships.

Pedagogical anxiety is a subject-anchored affective state in which a teacher experiences distress not merely from performance demands, but from perceived inadequacy in their subject-specific instructional repertoire (Cojorn & Sonsupap, 2022). In teacher education, this anxiety often becomes visible during practicum because student teachers must translate theoretical preparation into classroom action while dealing with performance expectations and external evaluation from supervisors. For that reason, pedagogical anxiety should be seen as a meaningful part of professional preparation rather than a temporary emotional disturbance (Gorospe, 2022).

In science education, pedagogical anxiety is also shaped by the demands of the subject being taught. Pre-service science teachers with higher anxiety tend to show lower self-efficacy for teaching science, while stronger confidence and more positive attitudes are associated with lower anxiety (Senler, 2016). This pattern is especially important in biology because many topics are abstract, complex, and dynamic, requiring teachers to use representations that make ideas more accessible to learners. When pre-service biology teachers are unsure how to transform difficult content into teachable material, anxiety may arise from the gap between academic knowledge and pedagogical performance (Bwalya et al., 2023).

Bandura's (1997) social cognitive theory establishes self-efficacy, which is beliefs about one's capacity to execute specific behaviors to achieve desired outcomes, as a central determinant of both affect and performance. In teacher education, higher teaching self-efficacy is associated

with reduced anxiety, greater persistence, and more varied instructional strategies (Klassen & Chiu, 2010). Conversely, low self-efficacy amplifies anxiety by increasing perceived threat and reducing tolerance for ambiguity in the classroom, especially when pre-service teachers feel unprepared to handle classroom complexity or instructional pressure (Gorospe, 2022). Efficacy beliefs are also shaped by attitudes and affective conditions, indicating that confidence in teaching develops not only from knowledge acquisition but also from emotional experience, making this important for biology education because anxiety may remain high even when students do not dislike biology, as long as they still doubt their ability to teach it well (Senler, 2016).

Self-efficacy can also be strengthened through meaningful success experiences. Improvements in science content understanding have been shown to accompany stronger science teaching self-efficacy, suggesting that confidence grows when pre-service teachers experience success in understanding and explaining disciplinary ideas (Menon & Sadler, 2016). This is particularly relevant for biology teacher education, where repeated opportunities to interpret content, explain it, and reflect on progress can build a more durable sense of professional competence (Bwalya et al., 2023).

The TPACK framework by Mishra & Koehler (2006) rooted in Shulman (1987) foundational work on Pedagogical Content Knowledge. This framework conceptualizes teacher knowledge as the dynamic intersection of three domains: Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK). TPACK represents the fully integrated form of this knowledge which concentrates on understanding how to make content-specific teaching experience elevated with the usable technology.

Studies in biology teacher education show that TPACK offers a productive framework for understanding teaching competence. Pre-service biology teachers who participated in TPACK-based coursework improved in overall TPACK as well as in several subdomains, indicating that integrated teacher knowledge can be strengthened through structured learning experiences (Bwalya et al., 2023). TPACK-based training also has been found to improve pre-service teachers' perceptions of competence across TPACK dimensions in addition, TPACK self-efficacy for material development has been associated with greater readiness to design instructional resources for science learning (Karakaya & Yazici, 2017). Together, these studies show that TPACK functions not only as a descriptive framework, but also as a practical basis for intervention because it helps future teachers organise teaching decisions more systematically.

E-modules have become increasingly important in teacher education because they can combine explanation, guided tasks, model examples, and reflection in a single structured environment (Diamah et al., 2022). Unlike printed materials, e-modules can guide pre-service teachers step by step from understanding a concept to applying it in lesson preparation and reviewing it through reflection. This makes them especially useful for supporting professional learning when student teachers need both flexibility and clear scaffolding (Diamah et al., 2022).

Recent studies suggest that digital intervention can strengthen both competence and confidence in pre-service teachers. Guided online training for pre-service biology teachers has been shown to improve self-efficacy, TPACK, and intention to use digital scaffolds in instruction (Offermann et al., 2025). More broadly, systematic review evidence on digital technology preparation in teacher education shows that effective intervention must be structured, practice-oriented, and pedagogically grounded rather than focused only on technical exposure (Tondeur et al., 2025). These findings indicate that digital support is most meaningful when it helps pre-service teachers connect instructional decisions to real teaching problems.

Reflection is also an important part of intervention. Reflective practice has been found to support the development of self-efficacy among pre-service teachers because it helps them examine struggles, reinterpret setbacks, and identify possible improvements in teaching

(Jonathans et al., 2025). In this sense, an e-module can function not only as an information source, but also as a guided reflective space that helps pre-service teachers process anxiety and gradually build confidence through more systematic learning experiences (Jonathans et al., 2025). Recent e-module development studies in Indonesian biology education demonstrate significant gains in pedagogical competence and reduced anxiety when modules are grounded in specific theoretical frameworks. However, no existing e-module specifically use the integrated lens of TPACK and self-efficacy, so this issue stands as a gap of this study's R&D project directly addresses. The present needs analysis provides the empirical foundation for that development work.

METHODS

This study employed a descriptive survey design as the needs analysis phase of a larger Research and Development (R&D). The descriptive approach is appropriate here as the goal is to systematically characterize the pedagogical anxiety profile of the sample rather than to establish causal relationships (Creswell & Creswell, 2023). The retrospective survey method mirrors the approach used by Pahmi et al. (2025) and is well-established in pre-service teacher research for capturing authentic practicum experiences.

The population comprised all biology education students from one academic cohort at a university located in West Java, Indonesia, who had completed the teaching internship program. A purposive sample of 32 participants was selected based on the inclusion criterion of having completed the program in the same academic year and in the same level of school (all the participants taught in senior high school). Purposive sampling was appropriate given the retrospective nature of the study, as only participants with direct teaching internship program experience could provide valid data.

Data were collected using a questionnaire was adapted from Pahmi et al. (2025), who developed and validated a mathematics pedagogical anxiety questionnaire grounded in a four-aspect framework. Adaptation involved replacing all mathematics-specific references with biology-specific equivalents, with particular attention to content complexity items. Table 1 presents the shows the distribution of questionnaire items based on the aspects examined in biology pedagogical anxiety.

The research instrument was a closed-ended questionnaire consisting of 18 items measured on a 4-point Likert scale (1 = Strongly disagree to 4 = Strongly Agree). Construct validity was assessed using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity. The results yielded a KMO value of 0.52, exceeding the minimum threshold of 0.50, and a Bartlett's Test significance of 0.000 ($p < 0.05$), confirming that the data were suitable for further analysis. Furthermore, the internal consistency of the instrument was evaluated using Cronbach's Alpha, resulting in a coefficient of 0.80, which indicates high reliability (Hair et al., 2019).

Table 1. Distribution of questionnaire items based on the aspects examined in pedagogical anxiety

Aspect		Question
Low self-confidence in biology ability		I feel confident that I can design an appropriate lesson plan.
		I feel worry about not having adequate resources to support my biology teaching.
		I feel worry about not being able to adapt my teaching methods for students with different abilities.
		I feel confident in using technology effectively to support my biology teaching.
Fear of failing to understand biology concepts		I feel confident that I can explain the material I teach clearly.
		I am afraid of not being able to answer students' complex questions.
		I always feel anxious when teaching biology topics that I find complex.
		I always stressful when preparing to teach a biology topic I am less familiar with.
Negative attitude toward biology		I feel confident that I can create assessments that align with the learning objectives I have designed.
		I always feel stressful when teaching in front of students.
		I always feel anxious when teaching in front of the supervising teacher.
		I feel tense when dealing with students who are uninterested in biology.
General fear of the subjects		I feel unenthusiasting when teaching biology.
		I feel worry that students may struggle to follow my teaching methods.
		I feel worry that students will fall behind in learning the material I teach.
		I feel anxious that your teaching methods may not capture students' attention effectively.
		I am afraid of not being able to cover all biology material within the planned time.
		I always feel nervous when managing a class that struggles with biology.

The questionnaire was administered during the semester following participants' completion of teaching internship program. Participants were explicitly instructed to reflect on and recall their anxiety experiences during the teaching internship period, consistent with the retrospective survey design. Informed consent was obtained from all participants prior to data collection. Anonymity was assured to minimize social desirability bias.

Descriptive statistics were computed for the overall pedagogical anxiety scale and for each of the four aspects based on mean. Individual participant scores were classified into anxiety categories based on the Zung's self-rating anxiety scale (SAS) from that has been widely used and validated to assess anxiety related to academic context (Pahmi et al., 2025). All analyses were conducted using IBM SPSS Statistics version 25. The pattern of aspect-level means was then interpreted in relation to TPACK theory and self-efficacy theory to derive implications for e-module design.

RESULT AND DISCUSSION

The findings of this study provide a clear empirical justification for the urgent development of pedagogical interventions for pre-service biology teachers. The data, as shown in Figure 1, shows that teaching anxiety is not a peripheral issue but a central challenge, with 56% of respondents falling into the mild to marked to severe anxiety levels and extreme anxiety levels categories. This distribution, particularly the 9% of students in the extreme anxiety levels category, suggests that for a significant portion of student-teachers, the teaching internship is a high-stress experience that could potentially hinder their professional growth.

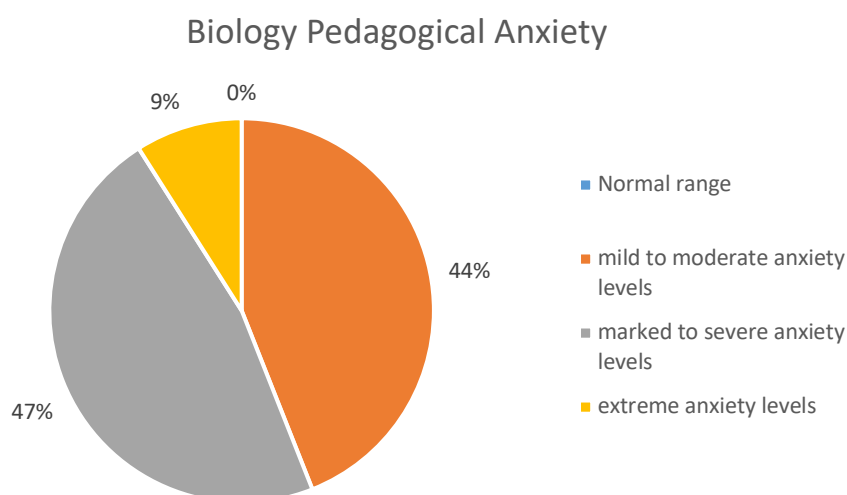


Figure 1. Percentage of pedagogical anxiety levels

To interpret the levels of biology pedagogical anxiety in each level, the mean scores were categorized into four levels using an equal-interval scale. The four-level classification (Low, Moderate, High, and Very High) was chosen to provide a clearer distinction between students who require intervention and those who do not, effectively eliminating the neutral midpoint bias often found in 5-point scales. Table 2 presents the descriptive statistics for overall and each of the four aspects.

Table 2. Descriptive statistic of pedagogical anxiety aspects

Aspect	M	SD	Category
Low self-confidence in biology ability	2.35	0.63	Moderate
Fear of failing to understand biology concepts	2.55	0.73	High
Negative attitude toward biology	2.40	0.91	Moderate
General fear of the subjects	3.08	0.78	High
Overall Aspect	2.59	0.76	High

Note. Scale: 1.00–1.75 = Low; 1.76–2.50 = Moderate;
2.51–3.25 = High; 3.26–4.00 = Very High. $n = 32$.

Overall, the collective mean score across all dimensions stands at 2.59, which falls into the high category. This indicates that teaching anxiety is not localized to a single issue but is a multi-faceted pressure that affects the students' pedagogical readiness. The standard deviation ranging from 0.6 to 0.9 indicate that individuals experienced pedagogical challenges differently, ranging from mild apprehension to significant distress. These findings linear with Riaz et al. (2023) that measured the anxiety of pre-service teacher at initial, during, and final stages and found that anxiety was present at all stages and particularly high early on. That also means the pre-service

teachers who just have their first teaching experience in school have higher anxiety than they who familiar with teaching practice.

Looking closely at the high-level contributors, Aspect 4 (General Fear of the Subject) emerged as the most significant stressor with a mean score of 3.08 (High). This finding is critical as it highlights that the primary source of distress is a broad apprehension toward the subject matter itself, including concerns about the anxiety if the methods may not capture student's attention effectively which results the most high result. The teaching anxiousness arises when teachers struggle to capture students' attention, feel unprepared, encounter unexpected events in class, and face unpredictable questions (Salsabila & Zaki, 2024)

This is closely followed by Aspect 2 (Fear of Failing to Understand Biology Concepts) with a mean of 2.55 (High). The most intense anxiety within this aspect arises when pre-service teachers imagine having to teach concepts they themselves still find difficult to understand. This is a pattern that mirrors evidence that science learning anxiety and unresolved misconceptions can undermine pre-service teachers' confidence when they are required to explain complex content in front of students (Amelia et al., 2026; White & Newby, 2024).

In contrast, while still requiring attention, Aspect 1 (Low Self-Confidence in Biology Ability) and Aspect 3 (Negative Attitude toward Biology) recorded lower mean scores of 2.35 and 2.40, respectively, placing them in the Moderate category. Although these aspects are not as critical as the general fear of the subject, they provide a baseline of psychological vulnerability. Previous research has similarly reported that pre-service science teachers tend to have high academic self-efficacy and motivation toward biology, with only a small portion of their variance explained by test anxiety (Ates & Saylan, 2015). In addition, studies on in-service and pre-service biology teachers show moderate to positive biology-teaching self-efficacy and generally favorable attitudes toward teaching the subject (Tzovla & Kedraka, 2020). The fact that 'Attitude' and 'Self-Confidence' are lower than 'General Fear' indicates that the pre-service teacher actually have a relatively positive stance and basic confidence, but they feel "overwhelmed" once they face the actual complexity of teaching in the authentic classrooms.

The overall high level of biology pedagogical anxiety observed in this retrospective sample should not be interpreted as an absence of concern. It is therefore likely that anxiety during the teaching internship program was higher than the retrospective scores suggest. Moreover, as Pahmi et al. (2025) note, even moderate pedagogical anxiety can impair communication clarity, reduce pedagogical strategy flexibility, and lead to avoidance of challenging content, all of which are consequential in the classroom. The moderate pedagogical anxiety documented here thus constitutes a legitimate signal that structured support during, rather than only before, the teaching internship program is warranted. In this context, the university curriculum has an important but still incomplete role in preparing pre-service biology teachers because it provides opportunities to connect subject knowledge, teaching methods, and classroom practice, yet the persistence of anxiety suggests that this preparation has not fully met students' needs (Megawati & Astutik, 2018; Tafli, 2021).

Prior studies show that self-efficacy in lesson planning, assessment, and classroom management reflects how well the curriculum prepares students for professional teaching tasks, while biology candidates from education faculties tend to show stronger TPACK self-efficacy than those from non-education pathways (Muthmainnah & Nurkamilah, 2022; Maknun et al., 2025). Practicum models that explicitly combine technological, pedagogical, and content knowledge have also been shown to improve prospective biology teachers' self-efficacy, which means that the present anxiety findings point to an urgent need for a structured intervention as a bridging support between university preparation and school internship (Maknun et al., 2025). In this way, the e-module is not merely an additional resource, but a necessary response to the remaining gap between curriculum-based preparation and the demands of real teaching practice.

The finding that the "anxiety core" centres on a general fear of biology and a fear of failing to understand concepts deeply enough to teach them suggests that these students do not need

more abstract theory, but rather support in organising how they think about teaching difficult content. This interpretation is consistent with work on science learning anxiety showing that anxiety can disrupt pre-service teachers' engagement with scientific ideas and potentially undermine their future teaching if it is not addressed through pedagogically meaningful support (Amelia et al., 2026). At the same time, research on TPACK-based training programmes indicates that when pre-service teachers are explicitly guided to see how technological, pedagogical, and content knowledge fit together, their perceived TPACK increases significantly, which in turn makes them more confident in planning and delivering subject lessons (Diamah et al., 2022).

On this basis, placing TPACK understanding as the first strand in the e-module is not arbitrary; it directly responds to the pattern of anxiety in this study by turning a vague sense of being “overwhelmed” into a clearer, more integrated way of thinking about teaching biology. Content representation making and lesson planning that is explicitly built around those representations, translate this conceptual understanding into concrete teaching decisions at exactly the points where participants reported the most anxiety. Designing visualisations, simulations, or other representations for biology concepts that they personally find difficult forces pre-service teachers to grapple with content and pedagogy together, rather than treating them as separate tasks. This design choice is in line with Bandura's argument that mastery experiences with challenging tasks are the most powerful source of growth in self-efficacy, and with empirical work showing that guided practice with complex teaching tasks can indeed raise teacher self-efficacy over time (Pfitzner-Eden, 2016)

Evidence from TPACK-based e-module development and training in other subjects further suggests that when pre-service teachers repeatedly design and refine technology-enhanced lessons, they not only improve their conceptual and pedagogical understanding but also reduce their uncertainty about integrating technology in real classrooms (Meika et al., 2026; Priyanda et al., 2026; Aziez et al., 2025). In a similar vein, a TPACK-based technology integration course for pre-service biology teachers was found to strengthen both TPACK and their intention to use digital tools, particularly when it involved designing lessons on demanding science topics and revisiting those designs in light of feedback (Offermann et al., 2025). Taken together, these studies support the idea that an e-module centred on representation making and representation-driven planning directly targets the key anxiety dimensions identified in this study while simultaneously engineering structured mastery experiences that can build self-efficacy.

The final strand, guided reflection is designed to give pre-service teachers a safe space to name their struggles, make sense of them, and plan how to respond. Research on reflective practice in teacher education shows that when pre-service teachers engage in systematic reflection, they are more likely to reinterpret difficulties not as signs that they are “not meant” to teach, but as part of a normal learning process, and this reframing is associated with gains in pedagogical self-efficacy and more resilient professional identities (Jonathans et al., 2025; Li, 2025). Studies on the role of emotion and reflection in teacher development likewise suggest that structured reflection helps pre-service teachers process negative emotions, including anxiety, and integrate them into a more coherent sense of agency instead of withdrawing from challenging situations (Schlosser & Paetsch, 2023). A recent systematic review and meta-analysis of teacher self-efficacy interventions concludes that the most effective programmes combine mastery experiences with opportunities for guided reflection, allowing teachers to connect what they did, how they felt, and what they might try next in a way that strengthens self-efficacy (Täschner et al., 2025). In this study, the anxiety profile has therefore been used not only to decide *what* should be included in the e-module (TPACK concepts, representations, plans, reflections), but also how those elements are sequenced so that pre-service biology teachers are gradually supported to think more systematically about their teaching and to replace persistent anxiety with evidence-based confidence in their ability to plan and enact biology lessons.

Several limitations should be acknowledged. First, the retrospective design introduces recall bias, likely resulting in underestimation of anxiety levels experienced during teaching

internship program. Future research should administer the instruments concurrently during practicum. Second, the single-cohort, limited research samples hinder the generalizability of the results to a broader population. Therefore, replication across multiple cohorts and institutions is recommended. Third, relying solely on quantitative survey data may restrict the depth of understanding regarding participants' nuanced experiences. Future studies could incorporate qualitative interviews to provide richer context and deeper insights into the specific challenges faced by the pre-service teachers.

CONCLUSION

High levels of pedagogical anxiety among pre-service biology teachers were identified, primarily driven by general fear of the subject and fear of failing to understand concepts deeply enough to teach them, despite moderate self-confidence and attitudes. These findings fulfill the research objective by empirically demonstrating that such multi-faceted anxiety impairs pedagogical readiness during teaching internships, consistent with prior studies on science teacher stress and its classroom consequences. This research implies that the development of the proposed TPACK-based e-module should produce a sequenced intervention that directly addresses core sources of biology anxiety: explicit TPACK integration to clarify overwhelming content–pedagogy links, representation-making to create mastery experiences with challenging topics, and guided self-efficacy reflection to build resilience. The design contributes by operationalizing TPACK training principles (for example, lesson design and feedback cycles) specifically for anxiety reduction in biology, and by extending evidence from self-efficacy and reflective-practice research into authentic internship contexts. Ultimately, deploying the e-module during internships provides empirical justification for transforming anxiety into competence, enhancing pre-service teachers' ability to deliver effective biology lessons and supporting long-term professional growth.

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