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The Antecedents of Artificial Intelligence-induced Pedagogical Designing Technostress among International Science Educators: Latent Content Insights from Reddit Commentaries

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Abstract

Artificial intelligence (AI) is rapidly advancing and increasingly embedded in education, provoking debates on its detrimental effects on teaching and learning, particularly within highly structured disciplines such as the sciences. This study examined the antecedents of Artificial Intelligence-induced Pedagogical Designing Technostress by analysing commentaries posted by science educators from diverse countries who actively engage in professional exchanges and discourses on Reddit. From a total of 210 datasets, collected through a meticulous Python- and Theoretical Framework-assisted data scraping process and verified manually for contextual integrity, the study employed Latent Content Analysis to chart the science educators-Redditors' lived experiences across science-related subreddits. Three (3) themes emerged: *Disruptions to Coherent Science Lesson Design*, *Uncertainties in Science Pedagogical Integration*, and *Pressures of Efficiency-Propelled Science Instruction*. Theoretically, the inquiry extends conceptualisations of technostress by situating it at the intersection of AI and pedagogical designing, demonstrating how algorithmic mediation reshapes science educators' epistemic and ethical responsibilities. Practically, it underscores the urgency to move beyond fragmented experimentation and develop structured institutional mechanisms and professional development pathways that equip science educators to critically appraise AI-generated content while preserving disciplinary autonomy.

Keywords: artificial intelligence, pedagogical designing, technostress, science educator, Reddit, latent content analysis

1. Introduction

Artificial intelligence ("***AI***") has rapidly shifted from the peripheries of technological speculation to the centre of modern human activity and productivity (Butson & Spronken-Smith, 2024). Its applications now permeate industries as diverse as healthcare, finance, communication, and education (Walter, 2024). With the proliferation of agentic generative systems, including large language models (LLMs), such as the Chat Generative Pre-trained Transformer (ChatGPT), and intelligent tutoring systems, AI has acquired unprecedented dominance in shaping knowledge creation and dissemination (Burger et al., 2023). The release of ChatGPT-5 in 2025 further reinforced this upward trajectory, placing AI at the focus of professional practice and amplifying expectations of its use in schools and universities (OpenAI, 2025). The education sector, long marked by gradual reforms, now confronts a decisive technological turning point where AI not only supplements but also redefines how teaching is conceptualised and executed.

The impact of AI in education remains deeply paradoxical. On one hand, AI promises considerable efficiency, streamlining routine work such as test item generation, lesson planning assistance, and administrative tracking (Labadze et al., 2023). Content creation, workflow automation, and chatbots functioning as teaching assistants open new opportunities for productivity. In stark contrast, these affordances risk distorting the educational endeavour. Brisk teaching facilitated by predictive tools may dilute carefully structured pedagogical sequences, with AI sometimes yielding scientific inaccuracies, hallucinations of data, or formulaic phrasing (Taufikin et al., 2024). Despite attempts to humanise outputs, educators face the possibility of academic malpractice and negligence if they rely on AI without thoughtful restraint. Almasri (2024) contends that such dilemmas are particularly prominent in science education, where precision, methodological rigour, and developmental appropriateness remain non-negotiable in the facilitation of teaching and learning.

At the core of this tension is the act of Pedagogical Designing ("***PD***"). Operationally, it is the applied dimension of pedagogical content knowledge (PCK), the 'special amalgam of content and pedagogy that is uniquely the province of teachers' (Shulman, 1987, p. 8). PD refers to systematically planning learning activities, teaching-learning episodes, and assessment tools grounded in instructional philosophies, precepts, theories, and contextual realities (Davis et al., 2011). In the realm of professional education praxis, the 'pedagogical design capacity' (Knight-Bardsley & McNeill, 2016, p. 645) ought to be embodied by educators, who entail curating lessons that scaffold inquiry, emphasise conceptual understanding, and balance cognitive, affective, and psychomotor learning outcomes. Tellingly, judicious PD, especially in science teaching, ensures that learners engage with scientific processes, from hypothesising and experimenting to critical reflection (Saribas & Ceyhan, 2015). The intrusion of AI into these processes can support and compromise such aims. If AI tools are utilised prudently, they may enrich science educators' repertoire of strategies. However, if such educators reduce lesson design to predictive algorithms, science education risks losing its investigative depth and degenerating into selective learning design detached from authentic scientific practice.

Contemporary science education scholars argue that the intersection between technological platforms, such as AI, and pedagogical knowledge frameworks warrants closer examination. Frameworks such as Technological Pedagogical Content Knowledge (TPACK) highlight the intersections between content expertise, pedagogical skill, and technological fluency (Sheffield et al., 2015). In science education, AI alters these construct intersections in complex ways. AI strengthens technological knowledge (TK) and reshapes technological content knowledge

(TCK) by providing novel simulations, visualisations, or adaptive experiments. However, PCK, and eventually PD, which require mindful consideration of learners' misconceptions and disciplinary difficulties, cannot simply be delegated to machines. Filiz and associates (2025) posited that educators must adapt to AI, exercising change management while ensuring that scientific content is taught with fidelity. The evolving regulatory landscape only magnifies the stakes, as policies in many contexts remain underdeveloped in responding to the rapid proliferation of AI tools (Doria, 2024).

Whether inward-tending or outside-looking, the wider socio-educational and technological environment reinforces this urgency. Digital democracy and citizenship now frame how learners access and engage with knowledge (Christensen et al., 2021). In science education, the democratisation of resources means that students increasingly explore laboratory simulations or problem-solving platforms independent of educators (Kolil & Achuthan, 2024). While this represents a positive expansion of opportunities, it also raises risks of AI misuse and abuse, including exposure to oversimplified explanations or misleading outputs. Siason (2021) noted that Competent and Responsive Education (CaRE) requires educators to safeguard the disciplinary integrity of teaching. In the larger purview of this inquiry, this meant ensuring that AI functions only as an agent or conduit of learning, not as a replacement for pedagogical judgment.

Science educators, however, confront mounting pressures amidst the evolving demands of 21st century science education. Heavy workloads, performance expectations, and the demand for constant adaptation to technology create fertile ground for Technostress ("***TS***"). Defined as the psychological, emotional, and behavioural strain experienced when technological demands exceed adaptive capacities, TS manifests in anxiety, fatigue, and diminished teaching quality (Li & Wang, 2021). The condition is intensified in science classrooms, where lesson design must anticipate laboratory work, project-based activities, and complex assessments. The risk lies in educators' well-being and in students' diminished opportunities to develop critical, creative, and reflective thinking through authentic scientific tasks (Upadhyaya & Vrinda, 2021).

Despite these risks, international bodies continue to advocate the active embedding of AI into education. The Programme for International Student Assessment (PISA) 2029, for instance, will incorporate *Media and AI Literacy* (MAIL) as a new domain, reinforcing the expectation that students and educators engage with AI (Media & Learning, 2025). However, science educators navigate this terrain without robust pedagogical taxonomies of AI integration. The authors argue that the novelty of AI in education, the worrying pattern of AI misconduct, and the unsettled frameworks of pedagogical adaptation all contribute to Artificial Intelligence-induced Pedagogical Designing Technostress ("***AIPDTS***"). Learning facilitators often resort to AI to meet deadlines or standards, but in doing so, may lose touch with the relational and inquiry-driven nature of science teaching (Park et al., 2023). When this dimension is side-tracked, the potential to harness AI as a catalyst for deeper inquiry, creative exploration, and relationally grounded science learning is left unrealised.

Although recent research has examined TS in general educational contexts (Bourlakis et al., 2023), there remains a scarcity in the extant literature on how AI specifically shapes the PD of science educators while actively avoiding the perils of TS. This represents a critical blank spot requiring urgent scholarly attention as 21st century science teaching intersects cognitive demands, technological innovation, and ethical responsibility. To surface these dynamics, it is essential to examine the candid voices regarding the antecedents of AIPDTS among science educators far and wide. Online discussion fora, such as *Reddit*, provide in-depth avenues for such intellectualised expressions, offering a distinctive advantage over conventional data sources such as plain interviews (Karnovsky & Gobby, 2024). Its anonymity allows science educator-*Redditors* (Reddit users) to articulate the origins of concerns, apprehensions, and misgivings about AI integration in science with candour, free from institutional censorship or professional constraints (Staudt-Willet & Carpenter, 2020). The international composition of the *subreddits* (thematic discussion fora) in this inquiry ensured that perspectives are drawn from diverse educational systems, enriching the scope of analysis and capturing the global resonance of TS in science education. The dialogical structure of such threads further revealed how ideas are debated and portrayed, offering insights into individual reflections and collective meaning-making. For a phenomenon as emergent and sensitive as AIPDTS, Reddit served as a dynamic and context-rich arena for the emergence of latent perspectives related to the nature of this study. Such a lived experience is a text that needs to be read.

Considering these arguments, this qualitative study purported to answer the **central research question:** *What latent themes characterise the antecedents of AIPDTS among international science educators, as discerned from Reddit commentaries?*

2. Theoretical Framework

The Mutually Engaging Encounter with Technology ("***MEET***"), a theoretical underpinning popularised in a grandparenting-technology study (Gonzalez et al., 2025), offered a strong conceptual anchorage for examining the antecedents of AIPDTS among international science educators. It emphasises the value of sustained, reciprocal, and healthy engagement with technology. In this inquiry, it suggests that science educators can collectively maximise the pedagogical potential of AI only when their utilisation remain balanced rather than stress-inducing. By situating TS within mutuality and symbiotic dynamics, MEET enabled the identification of the origins of the stressors in PD while being open to the determination of actionable solutions that could reduce such strains while strengthening professional practice. Its alignment with the methodological nature of Latent Content Analysis ("***LCA***") further concretised the uncovering of educators' digital narratives from Reddit, providing nuanced insights into how AI reshapes teaching and learning in science education.

3. Methods

3.1. Research Design

LCA offered a robust means of unpacking the narratives among Redditors (Graneheim et al., 2017), revealing underlying antecedents of AI-induced TS in PD within science education that may remain hidden when examined solely through surveys or structured interviews. Unlike Manifest Content Analysis, which confines itself to surface-level analyses of words and phrases, LCA provides a more nuanced lens by interpreting the underlying intentions, assumptions, and tensions embedded in discourse. This distinction was crucial because the study was conducted on Reddit. On this platform, user interactions are mediated by anonymity and cultural subtexts that often blur explicit expression yet carry profound experiential meaning. Accordingly, LCA illuminated these deeper layers of meaning, allowing readers of this inquiry to easily understand the antecedents of TS as they unfold in AI-driven PD in science education.

3.2. Data Corpus Source (The International Science Educators-Redditors)

The data corpus comprised Reddit users self-identifying as science educators who actively engaged in discussions across internationally oriented subreddits such as r/*ScienceTeachers*, r/*Teachers*, r/*education*, and r/*edtech*, among others. These online communities are characterised by transnational membership, with contributors representing educational systems from countries including the United Kingdom, the United States, Canada, Australia, India, and the Philippines. The inclusion of such subreddits ensured that the dataset reflected an international professional discourse rather than a geographically bounded sample. Although the original posters' identities were anonymous in line with Reddit's data policies, clues such as language use, classroom examples, and mentions of different national curricula indicated that the commenters came from various countries. Consequently, the study treated these Redditors as an international cohort of science educators collectively articulating lived experiences and reflections on AIPDTS.

3.3. Data Gathering Procedure

3.3.1. Automated Searching Procedure

Automated data collection was conducted using Python version 3.13.7 and the Python Reddit API [Application Programming Interface] Wrapper (PRAW). The retrieval targeted a wide array of posts and comments containing the central keyword "*artificial intelligence*" or "*AI*" across multiple science education-related subreddits fielded by science educators from different countries within a predefined time frame. By anchoring the search on central keywords, the procedure lifted all instances in which such terminologies appeared in the history of various science education-related subreddits, ensuring comprehensive coverage of discussions in the chosen online fora. Metadata such as subreddit names and all associated comments were extracted, with error handling and automatic retries ensuring exhaustive reach in the script. The selected timeframe of January 2022 to July 2025 was intentionally configured to capture the evolving trajectory of AI integration in education, from its initial mainstream adoption to its pedagogical normalisation. This span allowed the study to make sense of the shifts in science educators' perceptions as generative AI tools progressed from experimental novelty to institutional utility. Limiting the data to this window ensured analytical coherence by focusing on the formative years when discourse around AI's educational value, risks, and professional implications was most dynamic and revealing.

FIGURE 1. '*A PRIORI*' TERMINOLOGIES FROM THE LITERATURE THAT MAY HINDER THE ATTAINMENT OF THE MEET

Source: Created by the first author via https://www.wordclouds.com/

To systematically identify TS-related content in the context of PD, the full dataset (n = 10,014 comments) was scrutinized to retain topic-sensitive remarks, providing a robust springboard for uncovering the antecedents of AIPDTS. Guided by the theoretical underpinning of the inquiry, certain *A priori*-derived keywords (see Figure 1) drawn from the related and extant literature that may potentially impede the attainment of the MEET, including "*stress*" (Delello et al., 2025), "*overload*" (Promsiri, 2025), "[early onset digital] *burnout*" (Duan & Zhao, 2024), "*fatigue*" (Julien, 2024), "*strain*" (Tang & Liao, 2025), "*pressure*" (Gayed, 2025), "*anxiety*" (Yalçin et al., 2024), and "[work-life] *imbalance*" (Huang & Zhao, 2025) were used to narrow down the resulting original dataset from the initial broad search. Applying these keywords in a subsequent Python processing, 210 comments were identified as directly linked to the TS experienced by the science educator-Redditors. The remaining 9,804 remarks were excluded from further analysis as they did not exhibit explicit connections to the adverse effects of AI on science educators' work and well-being during episodes of PD, and were not tagged as avenues to cull the antecedents of AIPDTS. Table 1 summarizes the number of included and excluded commentaries across identified subreddits.

TABLE 1. DISTRIBUTION OF TECHNOSTRESS (TS)-RELATED AND NON-RELATED COMMENTS PER SCIENCE EDUCATION-CENTRIC SUBREDDIT (2022–2025)

Science Education-related Subreddit	TS-related comments (*Included*)	TS-non-related comments (*Excluded*)	Total
r/Teachers	109	5000	5109
r/education	57	2000	2057
r/edtech	26	1500	1526
r/ScienceTeachers	11	800	811
r/teachingresources	5	300	305
r/CSEducation	2	100	102
r/PhysicsTeachers	0	50	50
r/ChemistryTeachers	0	50	50
r/AcademicTechnology	0	4	5
Grand Total	210	9804	10014

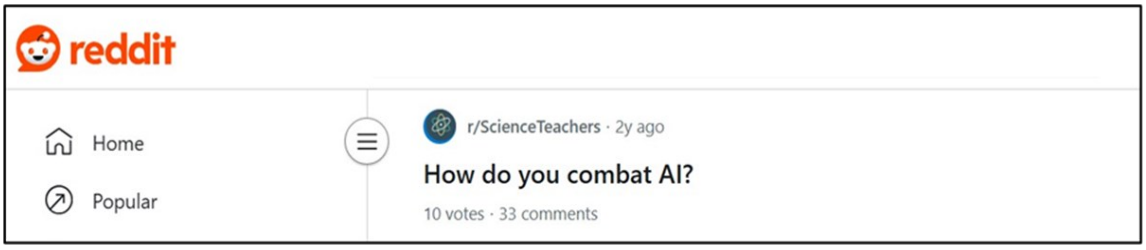
Source: Constructed by the first author from the Python data

From the initial pool of 10,014 comments, only 210 (≈ 2.1%) were tagged as directly related because the filtering and analytic procedures were intentionally stringent, focusing solely on comments that strongly reflected the construct of interest. This relatively small subset is expected in large online datasets where much of the discourse is tangential and off-topic. Notably, these 210 comments were contributed by different Redditors across multiple subreddits rather than concentrated in a single thread, making them a diverse yet focused core of data for generating meaningful insights.

3.3.2. Hand Searching Procedure

Building on the filtered dataset, verification of the significant comments through hand searching (Figure 2) transpired, guided by strict inclusion criteria to ensure its thematic potential and relevance, to wit: (a) content explicitly addressing AI in science PD or teaching strategy planning; (b) posts and commentaries written in English; and (c) publicly accessible content not originating from deleted, removed, or locked accounts. The manual searching modality enabled the verification of the most significant statements and identification of recurring patterns of AIPDTS, ensuring a rigorous and comprehensive thematic analysis of the international science educators' experiences. No remark has been tagged as loosely or partially related, resulting in all commentaries' retention (See Section 3.4.3). The targeted subreddit post analyses revealed that most TS-related comments among science educators originated from *r/Teachers* (n = 109), *r/education* (n = 57), *r/edtech* (n = 26), *r/ScienceTeachers* (n = 11), *r/teachingresources* (n = 5), and *r/CSEducation* [STEM-related] (n = 2).

FIGURE 2. A SAMPLE OF THE VERIFICATION OF A REDDIT POST AND ITS COMMENTARY CONTENTS THROUGH HAND SEARCHING



Source: Screen captured by the first author from https://www.reddit.com/

3.4. Mode of Analysis

3.4.1. The Qualitative Content Analysis (QCA) as the Theme Elicitation Technique

A total of two hundred and ten (210) significant remarks were ultimately subjected to LCA. The data reduction procedure adopted in this study followed the four-step process outlined by Bengtsson (2016) in QCA. Decontextualisation involved identifying meaning units from the significant comments, while Recontextualisation required verifying the inclusion of essential meaning units and excluding irrelevant or redundant ones. In the Categorisation stage, condensed meaning units were systematically grouped to generate categories or code clusters, which subsequently led to the development of themes in the Compilation stage, thereby uncovering the underlying meanings embedded in Redditors' discussions.

3.4.2. The Comprehensive Thematisation Trail of the QCA

Each comment was first assigned a provisional code corresponding to its semantic anchor, the explicit or implicit idea it conveyed about TS. Rather than grouping data immediately by theme, the coding distribution was initially mapped according to the subreddit of origin to preserve contextual nuance and discourse tone. This approach yielded a discernible trend in the distribution of coding frequencies across the six (6) subreddits (See Table 2), revealing distinct participation intensities in the construction of sub-themes. The subreddit r/*Teachers* emerged as the most prolific contributor, demonstrating strong thematic density in *Ambiguities in Science Practical Application* (n = 25) and *Incongruence Across Science Learning Concepts* (n = 25), followed by its significant input in *Restriction of Teacher Autonomy due to Prescriptive Outputs* (n = 20). This dominance indicates that educators in this forum primarily articulated challenges rooted in professional autonomy and contextual uncertainties of AI integration.

In contrast, r/*education* ranked second in overall frequency, contributing heavily to *Ambiguities in Science Practical Application* (n = 10) and *Misalignment with Science Pedagogical Goal*s (n = 11), as well as offering considerable data for *Incongruence Within a Science Learning Concept* (n = 11). Thematically, the comments from r/*education* displayed a recurring concern over epistemic instability, ethical-pedagogical divergence, and the pedagogical strain imposed by ambiguous institutional directives. Meanwhile, r/*edtech* accounted for moderate yet conceptually rich codes (n = 26), distributing its emphasis across nearly all sub-themes, particularly in *Incongruence Across Science Learning Concepts* (n = 8), *Misalignment with Science Pedagogical Goals* (n = 5), and *Restriction of Teacher Autonomy due to Prescriptive Outputs* (n = 2). This subreddit served as a critical locus of discourse on technological overreach and the algorithmic shaping of instructional routines.

The smaller but specialised subreddit r/*ScienceTeachers* (n = 11) contributed nuanced insights, primarily enriching sub-themes on epistemic misalignment (*Incongruence Across Science Learning Concepts*, n = 3) and reflective depth (*Prioritisation of Performative Speed over Pedagogical Depth*, n = 2). These contributions revealed discipline-specific apprehensions regarding conceptual coherence and professional identity in AI-mediated science instruction. By comparison, r/*teachingresources* (n = 5) and r/*CSEducation* (n = 2) registered the least coding activity, though their inclusions were instrumental in contextualising pragmatic concerns. The former provided evidence of pedagogical fatigue and verification-induced stress (*Incongruence Within a Science Learning Concept*, n = 3), while the latter captured the most technologically deterministic expressions under *Prioritisation of Performative Speed over Pedagogical Depth* (n = 2).

The subsequent coding process revealed distinct patterns of recurrence per subreddit, which subsequently guided the clustering of sub-themes. For instance, in r/*Teachers* and r/*education*, a large proportion of codes revolved around pedagogical mediation burden, implementation uncertainty, and institutional AI impositions, indicating collective concerns over professional role adaptation and workload redistribution. In contrast, r/*edtech* commentaries more frequently produced codes such as algorithmic dependency, technocentric governance, and automation-driven expediency, signalling heightened awareness of systemic pressures and ethical tensions in technology deployment. Meanwhile, r/*ScienceTeachers* and r/*teachingresources* foregrounded disrupted conceptual continuity, verification-induced stress, and pedagogical depth erosion, which directly informed the sub-thematic categories associated with the disciplinary and instructional challenges of AI integration.

TABLE 2. THE THEMATISATION TRAIL ACCENTUATING THE THEMES, SUB-THEMES, THEMATIC ORIGINS, AND CODING CLUSTERS OF AIPDTS

Major Theme	Sub-Theme	Brief Description of the Sub-Theme	Thematic Origin (Subreddit) and Total Coding Frequency Counts	Coding Cluster of Recurring Thought Elements per Subreddit
Disruptions to Coherent Science Lesson Design	Incongruence Across Science Learning Concepts	This sub-theme reflects how mismatched AI-generated materials across different science topics create confusion, forcing teachers to resolve issues	r/*ScienceTeachers* (3)	Curricular fragmentation Disrupted conceptual continuity
			r/*Teachers* (25)	Epistemic misalignment Pedagogical mediation burden

		between lessons and maintain curricular flow.	r/*education* (16)	Cognitive dissonance in lesson sequencing Unstable curricular reconstruction
			r/*edtech* (8)	Cross-disciplinary incongruity Pedagogical patchwork
	Incongruence Within a Science Learning Concept	This sub-theme captures teachers' struggles with AI tools that produce inconsistent or inaccurate scientific explanations, leading to mental fatigue as they constantly verify and correct flawed information.	r/*ScienceTeachers* (2)	Internal conceptual distortion Epistemic instability
			r/*education* (11)	Intratopic contradiction Reliability gap in AI outputs
			r/*edtech* (5)	Conceptual misrepresentation Verification-induced stress
			r/*teachingresources* (3)	Pedagogical error correction Threat to disciplinary authenticity
Uncertainties in Science Pedagogical Integration	Ambiguities in Science Practical Application	This sub-theme shows how unclear guidelines and inconsistent AI functions leave teachers uncertain about how to use such tools effectively in real classroom situations.	r/*Teachers* (25)	Implementation uncertainty Pedagogical role ambiguity
			r/*ScienceTeachers* (2)	Tool-context dissonance Institutional AI policy vagueness
			r/*edtech* (3)	Cognitive overload from unclear practices Improvisational teaching strain
			r/*education* (10)	Undefined professional expectations Structural ambiguity in AI integration
	Misalignment with Science Pedagogical Goals	This sub-theme highlights the tension between AI-driven shortcuts and	r/*education* (11)	Dilution of inquiry-based learning Technological overreach in pedagogy

		the deeper aims of science education, as overreliance on automation weakens students' inquiry and problem-solving habits.	r/*edtech* (5)	Reduced epistemic engagement Superficial learning due to AI
			r/*Teachers* (9)	Displacement of critical thinking Algorithmic dependency
			r/*ScienceTeachers* (2)	Ethical-pedagogical divergence Pedagogical authenticity erosion
Pressures of Efficiency-Propelled Science Instruction	Prioritisation of Performative Speed over Pedagogical Depth	This sub-theme refers to the growing emphasis on speed and efficiency in AI-assisted teaching, which risks undermining meaningful learning and reflective classroom practice.	r/*teachingresources* (2)	Efficiency–integrity paradox Superficial productivity
			r/*ScienceTeachers* (2)	Temporal pressure in instruction Compromised reflective teaching
			r/*edtech* (3)	Accelerated task orientation Cognitive bypassing
			r/*CSEducation* (2)	Pedagogical depth erosion Automation-driven expediency
	Restriction of Teacher Autonomy due to Prescriptive Outputs	This sub-theme reflects educators' frustration when imposed AI systems and policies limit their professional freedom to adapt teaching to students' needs and scientific contexts.	r/*Teachers* (20)	Institutional AI teaching imposition Erosion of professional agency
			r/*edtech* (2)	Technocentric governance Ethical unease and regulation gap
			r/*education* (9)	Pedagogical standardisation pressure Resistance to instructional homogenisation

Source: Constructed by the first author

These recurring codes were then subjected to iterative comparison, collapsing similar descriptors into conceptual clusters that represented the most salient meaning patterns within the dataset. This process produced the six (6) sub-themes, each grounded in an operational definition derived from the coding thought elements. For example, *Incongruence Across Science Learning Concepts* emerged from frequent references to curricular fragmentation, epistemic misalignment, and pedagogical patchwork, encapsulating the ways in which AI-generated content disrupted logical progression across topics. Similarly, *Ambiguities in Science Practical Application* was shaped by repeated mentions of implementation uncertainty, tool-context dissonance, and institutional policy vagueness, signifying the absence of coherent structures to guide AI usage in practical teaching contexts. These sub-themes thus represented the conceptual scaffolds upon which the educators' cognitive and emotional experiences of AI-induced pedagogical designing technostress were systematically interpreted.

Throughout the thematisation process, interpretative rigour was ensured through constant pairwise coder comparison and iterative memoing, enabling the analytic categories to remain faithful to the participants' discursive tone while still achieving conceptual abstraction. Each transition from code to sub-theme, and from sub-theme to major theme, adhered to the QCA principle of balancing manifest meaning (the explicit statements of educators) and latent meaning (the underlying tensions and pedagogical implications). The final thematic structure, therefore, did not merely categorise discourse but interpreted the layered experiences of science educators navigating AI's pedagogical and ethical frontiers, offering both descriptive coherence and theoretical depth.

3.4.3. Additional Vetting Procedure in the Processing of Coded Reddit Commentaries

All authors independently coded the complete dataset of 210 verified Reddit commentaries using a collaboratively developed codebook. To ascertain consistency across the coding process, Cohen's Kappa (κ) was computed through pairwise coder comparisons for all commentaries. Cohen's κ was employed as the statistical measure of intercoder reliability because it adjusts for the possibility of agreement occurring by chance, making it more rigorous than simple percent agreement. This statistic is particularly appropriate for QCA involving categorical coding decisions.

The analysis yielded Cohen's $\kappa = 0.863$, signifying a highly stable level of agreement per established statistical traditions (Landis & Koch, 1977). The observed agreement ($P_o = 0.886$) indicates that the two coders assigned the same sub-theme label to approximately 88.6% of the coded units. This means that in most cases, both coders independently agreed on how to categorize the data. Meanwhile, the expected agreement ($P_e = 0.164$) represents the proportion of agreement that could have occurred by chance. This means that in most cases, any overlap in coding decisions could simply be attributed to random coincidence rather than to a shared interpretation of the coding framework. By comparing these two values, Cohen's κ adjusts the observed agreement to account for agreement that may have arisen randomly. Thus, a high P_o and a low P_e, as in this case, indicate that the coders' agreement was systematic, meaningful, and not due to coincidence. Such a transparent, team-based validation process aligned with the methodological expectations of modern-day LCA inquiries, which emphasise coder verification and reliability calibration to reinforce subsequent analytical integrity (Obmerga et al., 2025).

3.5. Ethical Considerations

The study was exempted from formal ethical clearance upon review of Centro Escolar University – Coursework Publications under protocol code PRSE351-SY2025-26-1, as it did not involve direct contact and interaction with human participants. All data were sourced from publicly accessible online Reddit threads available at the time of collection, and no attempts were made to contact, identify, or interact with the individuals behind the usernames. To safeguard anonymity even within the bounds of fair use, any potentially identifying information was excluded from reporting. Norman-Adams (2024) cautions that reverse searching the identities of Reddit contributors using the quotes constitutes a potential ethical violation in data scraping. Hence, to avoid the involuntary identity disclosure of the original posters whose commentaries were presented in the findings, the authors rephrased the quotes, modifying their sentence structures while carefully preserving the literal meaning of the original expressions.

3.6. Trustworthiness and Rigour

To ensure the study's trustworthiness and rigour, the authors adhered to the Consolidated Criteria for Reporting Qualitative Research (COREQ) (Tong et al., 2007), concretising methodological transparency and completeness across all analytic stages. The inquiry explicitly conformed to key COREQ parameters, including researcher reflexivity, detailed description of data sources, procedural transparency in coding and thematisation, and explicit articulation of analytic decisions. Credibility was reinforced through full intercoder participation, yielding a Cohen's $\kappa = 0.863$, indicative of near-perfect reliability. Transferability was ensured by contextualising each sub-theme with illustrative commentaries that preserve educators-Redditors' intent, while dependability was secured through systematic documentation of coding decisions. For replication and auditability, the actual Python scripts used for automated data scraping (See Appendices A and B) are included in the supplementary materials, reinforcing the study's commitment to reproducibility within the evolving standards of LCA.

4. Results and Discussion

The LCA of Reddit commentaries yielded three (3) overarching themes that capture the antecedents of AIPDTS among science educator-Redditors. Disruptions to coherent science lesson design (Theme 1) show how science educators struggle to reconcile AI with disciplinary sequencing, a problem magnified by rigid accountability systems or fragile infrastructures. Uncertainties in science pedagogical integration (Theme 2) reveal that ambiguity and misalignment amplify stress when institutional guidance is absent. However, the triggers differ between industrialised contexts, where policy often outpaces practice, and developing loci, where resources remain uneven. Pressures of efficiency-propelled science instruction (Theme 3) highlight the paradox that while AI promises workload relief, it simultaneously erodes pedagogical depth and teacher autonomy, raising ethical and professional concerns across systems. Collectively, these findings articulate how TS is not simply a technological challenge but a pedagogical and psychological reality that reshapes contemporary science teaching.

4.1. Disruptions to Coherent Science Lesson Design

4.1.1. Incongruence Across Science Learning Concepts (Issues on Lessons' Intercoherence)

The LCA revealed a recurrent difficulty among international science educators: maintaining lesson intercoherence when integrating AI-generated instructional materials into the design of science lessons. Intercoherence, the logical sequencing and progressive connection of scientific ideas across topics, is central to pedagogical integrity in science, where conceptual knowledge builds cumulatively from simple to complex phenomena (Erdem, 2009). Yet, the data demonstrated that AI outputs often disrupted this structure, producing materials that conflicted with established curricular logics.

As one educator reflected in *r/ScienceTeachers*, "*The difficulty with AI is less about factual inaccuracies and more about the way it combines concepts in a manner that conflicts with how scientific knowledge is conventionally structured. I often find myself spending more time reorganising AI-generated ideas from different science topics than engaging in actual teaching*." This comment typifies the global frustration among science teachers who find themselves functioning less as designers of learning and more as curators of coherence. Another contributor from the same subreddit affirmed, "*Unlike AI, educators possess the capacity to shape horizontal learning through cross-cutting presentation of topics… guiding students towards authentic understanding even when the process feels less formal*." An educator on *r/Teachers* echoed this sentiment, emphasising that "*the burden placed on educators to reconcile disjointed or misaligned materials unfairly shifts the workload onto teachers rather than supporting their practice*."

These accounts illustrate that TS does not merely emerge from technological unfamiliarity but from the epistemic labour required to repair curricular inconsistencies generated by AI. The sensemaking process is mediated by national context. In highly structured educational systems such as the United States (Drost & Levine, 2017), England (Seleznyov, 2020), and Australia (Johnson et al., 2020), where curriculum coherence is strictly monitored, AI misalignments compromise both lesson sequencing and accountability frameworks. Conversely, in developing nations like the Philippines (Lazara & Morales, 2018) and India (Sardana & Muddgal, 2024), where curricular reforms coexist with infrastructural disparities, the same incoherence compounds pre-existing challenges of resource inequity and instructional fragmentation.

From a theoretical standpoint, this disjunction undermines Ausubel's (2000) theory of meaningful learning, which rests on the gradual assimilation of new knowledge into well-structured cognitive frameworks. When AI-generated materials interrupt the progression of scientific concepts, they risk forming fragmented understandings that crystallise into misconceptions, an outcome particularly concerning in inquiry-based science instruction. One educator in *r/Teachers* captured this risk aptly: "*Overreliance on AI introduces a disconnect between the essential knowledge students are expected to acquire and the content that is ultimately delivered*."

In sum, this sub-theme demonstrates that AI-induced lesson incoherence manifests as both a pedagogical and psychological strain. It heightens educators' workload, erodes confidence in algorithmic tools, and undermines the epistemological stability of science curricula. Nevertheless, some teachers transform this strain into professional skill-building—developing adaptive strategies to mediate AI inaccuracies, refine curricular links, and reinforce students' conceptual continuity. In this sense, while the antecedent of TS lies in AI-induced disruption, the educators' response embodies a form of reflective resilience that reclaims pedagogical agency.

4.1.2. Incongruence Within a Single Science Learning Concept (Issues on Lesson Intracoherence)

Science educators also reported significant challenges when AI-generated content conflicted within the boundaries of a single scientific concept, reflecting an intraconceptual incoherence that complicated lesson construction. One science facilitator cautioned, "*Even when limited to supporting a single lesson, AI tools like ChatGPT can still produce inaccuracies that teachers must contend with*" (r/*Teachers*). Another teacher elaborated with disciplinary precision: "*I sometimes employ AI to generate reading passages in my lesson activities, but close monitoring is essential since its accuracy is not guaranteed. For instance, when asked about the behaviour of water's freezing point under pressures below one atmosphere, the response required verification against a phase diagram*" (r/*ScienceTeachers*). These excerpts from Reddit commentaries exemplify how educators assume a gatekeeping role: filtering, validating, and recalibrating AI-generated material, to preserve conceptual precision and epistemic reliability within their lessons.

The cognitive and emotional demands associated with these tasks vary according to national and institutional contexts. In technologically advanced countries such as Japan (Lederman et al., 2021) and Germany (Zhai & Pellegrino, 2023), where curricula are anchored in rigorous scientific accuracy and inquiry-based assessment, even minor AI inaccuracies are perceived as professional liabilities, threatening educators' credibility and learners' performance in high-stakes environments. Conversely, in resource-limited contexts such as Nigeria (Onuoha & Chukwueke, 2023) and rural Indonesia (Suparjo et al., 2023), where access to verified instructional materials remains inconsistent, the intrusion of AI inaccuracies compounds existing inequities. As one educator reflected, "*I remain cautious about relying on AI as a lesson development aid, since without thorough review it can introduce inaccuracies and misleading details, particularly in technical science content*" (r/*education*).

These reflections underscore how AI-induced inconsistencies magnify the cognitive load of lesson preparation. According to cognitive load theory, reconciling contradictions within a concept imposes extraneous demands that drain teachers' working memory, restricting their capacity for more generative tasks such as designing inquiry scaffolds or promoting higher-order reasoning (Hanham et al., 2023). Within the LCA of this study, these tensions manifest as both technical adjustment and pedagogical authenticity issues, where science educators must uphold disciplinary validity even when assisted by imperfect AI tools (Akerson et al., 2014). For many science facilitators, the stress transcends factual correction; it involves safeguarding the epistemic credibility of science teaching (Peffer & Ramezani, 2019). Across both developed and developing educational systems, these dual demands, preserving conceptual accuracy and compensating for AI's shortcomings, amplify educators' cognitive strain and blur the distinction between technological assistance and pedagogical authority. Yet, through these struggles, educators demonstrate adaptive skill development, refining their evaluative judgement, critical literacy, and scientific communication capacities in the face of technological disruption.

4.2. Uncertainties in Science Pedagogical Integration

4.2.1. Ambiguities in Science Practical Application

The LCA also revealed a pervasive uncertainty regarding how AI-generated resources should be operationalised in everyday science teaching. As one educator shared, "*A lesson suggestion produced by AI may initially look accurate, yet the application is questionable and prerequisite concepts are omitted, leaving me confused if I will spend more time reorganising and rewriting than actually teaching*" (r/*Teachers*). Another echoed this concern: "*AI can provide factual content, but it lacks the connective logic that structures ideas; the progression becomes disrupted, and students miss the continuity essential for real application*" (r/*Teachers*). A third facilitator reinforced this sentiment, noting that "*Science textbooks are structured with a deliberate progression, whereas AI-generated lesson material tends to disregard that logic, producing fragmented content that disrupts students' skill development and confuses both teachers and students in the end*" (r/*Teachers*).

These commentaries reveal how science educators increasingly act as curricular interpreters, mediating between the promise of AI-generated materials and the epistemic discipline of science education. Rather than adopting such content uncritically, teachers engage in evaluative reconstruction: reorganising, verifying, and contextualising AI suggestions, to preserve conceptual accuracy and meaningful progression. In this process, however, ambiguity heightens workload and psychological strain. Educators frequently describe shielding learners from the uncertainties embedded in AI outputs, inadvertently reinforcing cognitive offloading, the transfer of mental effort to external tools (Gerlich, 2025), which risks eroding students' critical thinking and inquiry-based engagement with real-world scientific problems.

This tension manifests differently across global contexts. In Western education systems such as Canada (DeCoito, 2023) and Germany (Petrov, 2021), where technology integration is often rapid and policy-driven, ambiguity arises from the absence of clear institutional frameworks, compelling teachers to improvise pedagogical applications of AI without guidance. Conversely, in contexts such as Brazil (Hendges & dos Santos, 2023) and Vietnam (Nguyen & Pham, 2021), where access to digital infrastructure and teacher training remains uneven, ambiguity deepens as educators must adapt to unreliable technological conditions. One educator summarised this predicament: "*In the absence of AI tools tailored to science lesson realities, teachers are forced to improvise using lacklustre content, often generating more divergence than clarity*" (r/*Teachers*).

The resulting sense of dislocation aligns with Kahn and associates' (1964) role ambiguity framework, which posits that unclear expectations generate stress and undermine professional confidence. Within the domain of science education, where structured inquiry and conceptual precision underpin pedagogical assurance, such uncertainty can erode educators' sense of control and competence (Cairns, 2019). Consequently, science educators in industrialised contexts often interpret ambiguity as institutional misalignment, an outcome of accelerated technological adoption without adequate pedagogical integration, while those in developing systems view it as an extension of enduring structural inequities. Yet amid these tensions, educators display adaptive skill development: they refine their diagnostic judgement, meta-pedagogical awareness, and technological discernment, illustrating a professional resilience that redefines what it means to teach science in an AI-mediated world.

4.2.2. Misalignment with Science Pedagogical Goals

The LCA also revealed a recurring concern among science educators: AI-generated resources increasingly misalign with the deeper pedagogical goals of science education, where inquiry, perseverance, and conceptual growth are central. As one educator observed, "*Many students now abandon tasks prematurely, turning to AI almost instantly rather than engaging in even brief moments of struggle, which makes authentic perseverance feel increasingly out of reach*" (r/*education*). Another added, "*Learners carry immediate access to automated solutions in their pockets, making it unrealistic to expect them to consistently resist the temptation to bypass genuine problem-solving*" (r/*education*). These accounts underscore how habitual dependence on AI erodes productive struggle, a cornerstone of scientific learning. Instead of fostering the habits of mind that underpin scientific literacy, persistence, reasoning, and resilience in uncertainty (Nasr, 2021), students increasingly prioritise efficiency over depth, echoing a growing culture of intellectual shortsightedness.

Such pedagogical displacement threatens long-standing instructional frameworks. For instance, the Next Generation Science Standards (NGSS) in the United States emphasise authentic inquiry, modelling, and argumentation (Ford, 2015), yet educators reported that AI integration often disrupts these ideals by prioritising quick answers over the process of discovery. In response, science facilitators expressed a growing preoccupation with preserving the epistemic integrity of their lessons while simultaneously developing digital discernment skills, balancing the dual responsibility of innovating with technology and safeguarding pedagogical authenticity. One educator summarised this tension aptly: "*The growing emphasis on AI often seems to elevate the tool itself above the central purpose of science pedagogy*" (r/*edtech*).

In developing nations such as Kenya (Nzomo et al., 2023) and Bangladesh (Talukder et al., 2021), where reform efforts are still transitioning from rote-based methods to inquiry-oriented pedagogies, the challenge is magnified. AI tools, when uncritically used, risk re-entrenching passive learning behaviours rather than enabling active exploration. One teacher reflected, "*Since no AI-detection system is entirely reliable, evaluating each student submission becomes more like investigative work than grading, which leaves teachers feeling drained to recalibrate a future lesson's structure*" (r/*education*). This highlights how the burden of technological monitoring falls unevenly on educators, who must divert time from instructional innovation to ensuring authenticity and academic integrity.

From a theoretical perspective, Vygotsky's (1978) socio-cultural framework underscores why such misalignments are pedagogically significant. Science learning thrives on scaffolded interaction within the learner's zone of proximal development; AI shortcuts truncate this scaffolding, thereby diminishing both the educator's instructional agency and the learner's opportunity for meaningful cognitive struggle (Robertson & Atkins-Elliott, 2020). Consequently, science educators in industrialised contexts experience stress as inquiry traditions are hollowed out by algorithmic convenience, while those in developing systems confront the destabilising effect of stalled pedagogical reform. Yet, across both contexts, educators exhibit adaptive reflexivity, cultivating evaluative judgement, fostering digital ethics, and reaffirming science pedagogy's enduring mission: to teach not only what to know, but how to think.

4.3. Pressures of Efficiency-Propelled Science Instruction

4.3.1. Prioritisation of Performative Speed Over Pedagogical Depth

The last theme underscored the persistent tension between pedagogical integrity and the efficiency pressures that define modern science teaching. Science educators from varied national contexts acknowledged AI's remarkable utility in reducing cognitive and administrative load, yet simultaneously lamented its erosion of reflective teaching practice. As one educator admitted, "*This year, I began experimenting with an AI tool for planning assessment tasks, and while it was not flawless, it provided a useful starting point so I was not left staring at blank pages late at night*" (r/*teachingresources*). Another added, "*Written responses, as inputs from students to facilitate lesson planning, are still the most effective way to determine whether learners truly understand and to assess if they are genuinely invested in their learning. However, the process of carefully reading and responding takes considerable time. If AI could meaningfully assist with this task, it would genuinely be transformative*" (r/*teachingresources*). These reflections reveal that educators recognise AI's potential to ease workload pressures, particularly those linked to lesson design, assessment, and documentation, yet they remain wary of what is lost in the pursuit of speed.

Beneath this appreciation lies a deeper pedagogical unease: the fear that performative speed displaces authentic cognitive engagement. As expressed by a participant, "*AI-generated material often comes packed with facts, yet it lacks the depth or explanatory clarity needed to support real understanding of lessons*" (r/*ScienceTeachers*). This sentiment reflects a wider professional anxiety: AI facilitates faster task completion but may dilute the very qualities that make science education transformative: conceptual coherence, inquiry, and sustained reasoning. Across educational contexts, this dynamic manifests differently. In high-income countries such as the United States (Sutcher et al., 2019) and the United Kingdom (Johnson & Coleman, 2025), AI appears to offer respite from excessive administrative burdens and teacher shortages but simultaneously risks eroding inquiry-based approaches that underpin science literacy. In contrast, in developing contexts such as Kenya (Otieno et al., 2025) and Pakistan (Hussain et al., 2023), where class sizes are large and resources scarce, efficiency gains are valued but remain offset by the danger of superficial learning, a condition wherein speed masks shallow comprehension.

This paradox resonates with Postman's (1992) critique of technopoly, where efficiency-driven technologies displace deeper educational and cultural values. Similarly, Bruner (1960) posited that meaningful learning arises not from rapid information processing but from grappling with underlying principles through active exploration. The Reddit commentaries illustrate how educators internalise this conflict, describing an affective form of TS that stems less from the tools themselves than from the institutional expectation to do more, faster. One science facilitator warned, "*Relying on AI for instant answers risks undermining productive struggle, leaving students with superficial understanding rather than genuine cognitive growth*" (r/edtech). Another observed, "*Some students are now adept at polishing AI-generated work to make it appear authentically their own, which sidelines the deliberate and often demanding process of genuine scientific learning*" (r/edtech).

Ultimately, the pressures of efficiency-propelled instruction compel science educators to negotiate between two competing imperatives: sustaining humanistic, inquiry-rich pedagogies, and surviving within performance-oriented educational systems that cherish quick output over depth. From a TS perspective, the strain emerges not merely from increased workload, but from the existential dissonance between speed and substance, a collision that challenges the professional identity of science educators and redefines what it means to teach well in the age of AI.

4.3.2. Restriction of Teacher Autonomy due to Prescriptive Outputs

Finally, the science educators emphasised that, at times, the TS they experience did not originate from AI itself, but from how its adoption is enforced. One educator remarked, "*When I voiced concerns about our workload, I was immediately asked, 'Why aren't you using AI?', as though its use were mandatory*" (r/*Teachers*), revealing how managerial expectations often frame AI as a default solution rather than an optional tool. Another reflected, "*Professional development on AI often leaves us drained because it rarely translates into real classroom help*" (r/*edtech*). These accounts show how institutional directives, though well-intentioned, can reduce professional discretion to compliance.

Freire's (2000) critique of banking education aptly captures this dilemma: when educators are positioned merely as implementers of prescribed content or tools, authentic teaching agency is lost. Similarly, Selwyn (2016) argues that education technology policies often prioritise institutional efficiency over meaningful pedagogy, reinforcing hierarchical control. In such cases, science facilitators' autonomy, crucial for adapting lessons to context and inquiry-based goals, is constrained, heightening their sense of stress and disempowerment.

This phenomenon varies globally. In the United States, accountability systems equate technology use with innovation (Bush-Mecenas, 2022), while in China, top-down mandates limit contextual flexibility (Luo & Hsiao-Chin, 2023). In resource-limited contexts like the Philippines (Estrellado & Miranda, 2023) and South Africa (Funda & Mbangeleli, 2024), mandatory AI training often fails to address classroom realities. As one teacher warned, "*AI tools feel unreliable. One day they help, the next they confuse*" (r/*edtech*). From the lens of self-determination theory (Ryan & Deci, 2000), autonomy is essential for motivation and well-being. When educators are pressured to conform to prescriptive AI norms, stress and ethical unease escalate. Many teachers advocate clearer ethical frameworks that safeguard academic freedom and regulate AI bias. Mitigating these challenges calls for participatory policymaking, one that empowers educators to integrate AI adaptively, rather than coercively, into their PD.

5. The Researchers' Reflexivity

The researchers acknowledged the potential for confirmation bias, as the use of conceptually predefined search terms in the scraping process could have drawn more comments from educators already experiencing heightened AI-related challenges; however, these terms were purposefully guided by the study's theoretical framework to ensure conceptual alignment and analytical consistency. To mitigate other concerns, reflexivity was practised throughout the LCA by constantly reflecting on personal assumptions and analytic decisions. Several safeguards were applied: both researchers jointly coded the dataset, compared interpretations, and discussed differing views until agreement was reached; comments were read in their full thread context to avoid misinterpretation; and opposing views were intentionally included to balance emerging patterns. The researchers also kept reflexive notes to track how their insights evolved during analysis. While recognising that Reddit users tend to be more expressive about difficulties, the researchers treated this as valuable context rather than bias, interpreting the findings with caution and transparency.

6. Conclusion

Reddit, often revered as “the front page of the internet” (Norman-Adams, 2024, p. 48), provided a rich and dynamic source of discussions for examining the lived experiences of international science educators navigating the antecedents of AIPDTS. The findings revealed three (3) interlocking sources of the novel AI-propelled lesson-related strain being experienced by science educators far and wide. Theme 1 illuminates the disruptions to coherent lesson design, showing how AI destabilises the sequencing and interconnection of scientific concepts, compelling educators to balance disciplinary integrity with technological inconsistency. Theme 2 exposes the uncertainties in science pedagogical integration, demonstrating that in the absence of clear institutional direction, educators waver between cautious experimentation and professional disillusionment, particularly across unevenly resourced contexts. Theme 3 highlights the pressures of efficiency-propelled science instruction, capturing the paradox wherein AI offers workload relief yet simultaneously diminishes pedagogical depth and undermines teacher autonomy. The study’s theoretical contributions, practical implications, limitations, and future research directions are discussed below:

6.1. Theoretical Contributions

This research offers three (3) significant theoretical contributions. First, it advances TS-related inquiries by situating them within the discipline-specific demands of science education. In contrast, most prior studies have been confined to the context of general education (Bourlakis et al., 2023), healthcare (Issa et al., 2024; Lițan, 2025), and corporate work behaviours (Zhang et al., 2025). Second, it contributes to the emerging scholarship on AI in science education by positioning pedagogical design, not merely technological adoption, as the critical locus of analysis, marking one of the pioneering efforts to establish the nexus between AI and instructional planning modality. Third, by drawing on perspectives from international science educators, through Reddit commentaries, in both industrialised and developing contexts, the study contributes to a more nuanced understanding of stressors amidst the ongoing AI-borne paradigmatic shifts in science education, illustrating how efficiency-driven technologies intersect with differing systemic realities yet converge in producing similar strains on science educators’ epistemic and ethical responsibilities in PD.

6.2. Practical Implications

The present inquiry yields three (3) practical implications of direct relevance to science education; each purposively anchored from the emerged sub-themes. First, in light of the *Ambiguities in Science Practical Application* and *Misalignment with Science Pedagogical Goals*, educational institutions should design targeted capacity-building programmes that train science educators to critically evaluate AI-generated instructional outputs, aligning them with curricular logic and disciplinary sequencing. Policy frameworks must therefore articulate explicit operational guidelines that clarify the extent, purpose, and boundaries of AI utilisation in science teaching, supported by sufficient technological infrastructure and continuous pedagogical upskilling. Second, echoing the sub-themes of *Prioritisation of Performative Speed over Pedagogical Depth* and *Uncertainties in Science Pedagogical Integration*, teacher preparation institutions should develop professional learning initiatives that foreground AI literacy through inquiry-based and reflective models. Such initiatives must ensure that efficiency-driven teaching does not compromise the cultivation of scientific habits of mind: perseverance, critical inquiry, and evidence-based reasoning, that underpin meaningful science learning. Third, consistent with the sub-theme *Restriction of Teacher Autonomy due to Prescriptive Outputs*, educational institutions are urged to safeguard teachers' professional discretion by adopting participatory policy-making protocols. These mechanisms should allow science teachers to co-define how AI is integrated into classroom practice, preventing externally imposed technological mandates from diminishing autonomy or exacerbating technostress. Collectively, these implications emphasise that sustainable AI integration in science education requires institutional clarity, professional empowerment, and pedagogical balance between innovation and intellectual integrity.

6.3. Limitations

While this inquiry offers valuable insights, several limitations must be acknowledged. Since the study relies on Reddit data, the findings are based on voluntary and anonymous contributions, which may not adequately represent the broader population of basic and higher education science educators, may reflect imbalances across Western and Eastern cultural orientations, and pose challenges in verifying the identities of contributors. Yet, Reddit also functions as a window into unfiltered professional discourse, and its role as a form of "passive data collection" (Rocha-Silva et al., 2024, p. 455) offers access to candid reflections often absent from formal interviews. Moreover, the LCA provided systematic breadth, and while this involved some trade-off with contextual depth, it strengthened the capacity to capture wider trends across the dataset without losing sight of directions for more nuanced inquiry. Finally, it should be disclosed that AIPDTS is an original terminology coined and advanced by the authors and not yet a fully established construct in the literature. These limitations are mitigated by verification procedures, analytic transparency, and the study's exploratory intent, positioning the findings as provisional yet generative insights that warrant further empirical scrutiny across contexts and methodologies.

6.4. Future Research Directions

Future scholars are hereby encouraged to deepen and broaden the discourse on AIPDTS by exploring complementary methodological, theoretical, and empirical pathways that extend the present inquiry. On the qualitative front, digital autoethnography could provide first-hand narratives of how science educators navigate TS in their daily AIPD, revealing the lived and situated negotiations that remain inaccessible in Reddit-based analyses. Likewise, Glaserian grounded theory may be employed to theorise the iterative processes through which educators recognise, resist, and reframe AI-induced pressures, thereby capturing the evolving nature of adaptation and resilience in professional practice. Quantitatively, there is a compelling need to develop and validate psychometric tools specifically tailored to measure constructs of TS within AI-integrated science teaching contexts, ensuring that such measures are sensitive to cultural and contextual variations. To strengthen generalisability, subsequent inquiries should transcend the linguistic and cultural homogeneity of Reddit data by incorporating multilingual corpora and educator narratives from diverse educational systems and sociocultural settings. For direct replication efforts of the study, interested scholars who wish to conduct parallel inquiries may refer to the actual Python-assisted data scraping codes provided in the Appendices. They are encouraged to enrich the code to accommodate additional platforms, languages, or filtering parameters reflective of their local educational contexts and research foci. Doing so will not only strengthen methodological transparency and reproducibility but also enhance the intercultural validity and scalability of future AIPDTS investigations. Lastly, expanding the scope to include multiple online and offline data sources, such as Twitter/X, teacher blogs, professional learning communities, and institutional repositories, could offer a richer comparative lens.

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AI Use
The authors declare that any use of artificial intelligence tools in the preparation of this manuscript was limited to technical or language support, including the verification of the correctness and completeness of Python codes, and is transparently disclosed. The authors further affirm that all cited sources are real, accurately referenced, and have been verified by the authors. Full responsibility for the content and integrity of this article remains with the authors.

Ethics Statement
For studies involving human participants, the authors confirm that the research complied with relevant institutional and national ethical standards. Ethical approval was obtained where required, and informed consent was secured from all participants prior to data collection. If ethical approval was not required, the authors confirm that the study adhered to applicable ethical guidelines.

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Appendix A: The First Wave of Python-assisted Data Scraping Code/Script

```
import praw
import datetime

# --- Your Reddit credentials ---
reddit = praw.Reddit(
    client_id="REDACTED [TO INSERT YOUR OWN REDDIT CREDENTIALS]",
    client_secret="REDACTED [TO INSERT YOUR OWN REDDIT CREDENTIALS]",
    user_agent="AI_ScienceTeaching_Scraper"
)

# --- Search term ---
search_term = "artificial intelligence"

# --- Subreddits to check ---
subreddits = [
    "ScienceTeachers",
    "ScienceEducation",
    "PhysicsTeachers",
    "ChemistryTeachers",
    "Teachers",
    "EdTech",
    "AcademicTechnology"
]

# --- Storage ---
results = []

for sub in subreddits:
    print(f"\n Searching in r/{sub}...")
    subreddit = reddit.subreddit(sub)

    try:
        # safer search with error handling
        for submission in subreddit.search(search_term, limit=10, sort="new"):
            print(f"    Post: {submission.title} ({submission.url})")

            submission.comments.replace_more(limit=0)
            for comment in submission.comments.list():
                comment_date = datetime.datetime.fromtimestamp(comment.created_utc)
                results.append({
                    "subreddit": sub,
                    "post_title": submission.title,
                    "post_url": submission.url,
                    "comment": comment.body,
                    "date": comment_date.strftime("%Y-%m-%d %H:%M:%S")
                })

    except Exception as e:
        print(f"    Skipped r/{sub} due to error: {e}")

# --- Output ---
print("\n Finished extracting comments!")
print(f"Total extracted comments: {len(results)}")

with open("ai_science_comments_with_date.txt", "w", encoding="utf-8") as f:
    for r in results:
        f.write(f"[{r['subreddit']}] {r['post_title']} ({r['post_url']})\n")
        f.write(f"Date: {r['date']}\n")
        f.write(f"Comment: {r['comment']}\n\n")
```

Appendix B: The Second Wave of Python-assisted Data Scraping Code/Script

```
import pandas as pd
import re

# === SETTINGS ===
CSV_FILE = "reddit_ai_teaching.csv"      # input CSV (must be on Desktop with this script)
OUTPUT_FILE = "ai_technostress.csv"      # output CSV with filtered comments

# === STEP 1: LOAD CSV ===
try:
    df = pd.read_csv(CSV_FILE, encoding="utf-8")
except UnicodeDecodeError:
    df = pd.read_csv(CSV_FILE, encoding="latin-1")

print(f"\n Loaded file with {len(df)} rows")
print(" Columns found:", df.columns.tolist())

# Make sure we have the right column
if "comment" not in df.columns:
    raise ValueError(" ERROR: No 'comment' column found in the CSV. Please check column names.")

# === STEP 2: DEFINE NEGATIVE AI TERMS ===
negative_terms = [
    "stress", "overload", "burnout",
    "fatigue", "strain", "pressure", "anxiety",
    "imbalance"
]

# Allow both "AI" and "Artificial Intelligence"
pattern_ai = r"(?:\bai\b|artificial[\s\-]*intelligence)"

# Build regex patterns (both orders: AI → term, term → AI)
patterns = []
for term in negative_terms:
    t = re.escape(term)
    patterns.append(re.compile(rf"{pattern_ai}(.{{0,50}}?){t}", re.IGNORECASE))
    patterns.append(re.compile(rf"{t}(.{{0,50}}?){pattern_ai}", re.IGNORECASE))

# === STEP 3: FILTER FUNCTION ===
def is_ai_stress(text):
    text = str(text).lower()
    return any(p.search(text) for p in patterns)

df["related"] = df["comment"].apply(is_ai_stress)

# === STEP 4: SPLIT DATA ===
related = df[df["related"] == True]
excluded = df[df["related"] == False]

# === STEP 5: SAVE OUTPUT ===
related.to_csv(OUTPUT_FILE, index=False, encoding="utf-8-sig")

# === STEP 6: SUMMARY ===
print("\n AI-Related Technostress Analysis")
print(f"    Total comments: {len(df)}")
print(f"    Related to AI stress: {len(related)}")
print(f"    Not related: {len(excluded)}")

if "subreddit" in df.columns:
    print("\n Breakdown by subreddit (related only):")
    print(related["subreddit"].value_counts())

print("\n Sample related comments:\n")
for i, row in related.head(10).iterrows():
    print(f"- {row['comment'][:200]}...\n")

print(f" Saved results to: {OUTPUT_FILE}")
```