

Stress during teaching and instructional supervision in Thai pre-service teachers: regression analysis

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ABSTRACT

Pre-service teachers frequently experience stress and emotional challenges during the teaching practicum, which may influence their professional development and instructional effectiveness. This study aims to examine emotional challenges experienced during the practicum, compare stress levels across instructional supervision modalities, and identify factors associated with stress during teaching and supervision. The study contributes comparative evidence by analysing three supervision formats and modelling teaching-related stress and supervision-related stress as distinct outcomes. A quantitative cross-sectional survey was conducted with 208 pre-service teachers from a Thai public university. Data were analysed using descriptive statistics and multiple regression analysis. The results show that many participants reported reduced stress after several teaching periods, although a subgroup experienced persistent stress throughout the semester. Stress levels differed across supervision methods, with the highest stress reported during on-site supervision, followed by online and video-based supervision. Regression results indicate that the number of subjects taught significantly predicted teaching-related stress, while gender and number of subjects taught predicted supervision-related stress. These findings highlight the importance of workload management and structured mentoring in supporting pre-service teachers' emotional well-being and may inform the design of practicum supervision models in teacher education.

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1. INTRODUCTION

The global landscape of teacher education is undergoing a significant transformation as education systems strive to meet the needs of 21st-century learners. Worldwide, teacher preparation programs increasingly emphasize integrating innovative teaching methods, digital tools, and socio-emotional competencies to enhance learning outcomes [1]. However, the transition from theoretical preparation to real classroom practice often exposes pre-service teachers to substantial emotional and professional pressures during the teaching practicum. At the same time, global education agendas continue to emphasize equipping teachers with essential competencies such as critical thinking, creativity, and adaptability to support inclusive and lifelong learning [2].

In Thailand, education reform aims to produce learners equipped with essential skills and desirable attributes that align with the country's development goals [3]. Teachers play a vital role in this process and

are expected to demonstrate professional knowledge, teaching competencies, and a lifelong learning mindset while applying innovative pedagogical approaches. In teacher education, professional experience training is therefore designed to connect theory with practice and to support the development of professional competencies and preparedness for future teaching roles [4].

During the teaching practicum, pre-service teachers perform responsibilities similar to those of professional teachers, such as lesson planning, student guidance, and other school-based professional tasks [5]. This transition from student to teacher often causes stress as pre-service teachers adjust to their professional roles and new environments, which may affect both physical and mental well-being [6]. Moreover, teaching requires emotional control, as pre-service teachers frequently encounter challenging emotions such as anxiety, frustration, excitement, or fear, which may influence classroom relationships and instructional effectiveness [7]–[10].

Instructional supervision and evaluation are essential components of the practicum. However, they can also increase stress levels. During the practicum, pre-service teachers are observed, guided, and assessed by mentor teachers and university supervisors in various aspects of their teaching performance, particularly instructional planning, professional guidance, and practicum preparation [11]. The pressure to perform well during the practicum may contribute to anxiety and emotional strain among pre-service teachers, which may in turn affect their confidence and classroom performance [10]. In addition, stressors such as workload related to teaching as well as duties beyond teaching (e.g., administrative tasks, documentation, and practicum requirements), disruptive student behavior, time-management pressures, and professional expectations for emotional readiness to cope with instructional challenges may affect pre-service teachers' overall well-being and teaching performance [12]–[15]. High stress levels can result in physical problems, including insomnia and migraines, as well as psychological issues such as depression and burnout, which may eventually lead to program withdrawal [16]–[18].

Although previous studies have extensively examined stress and emotional experiences among pre-service teachers during teaching practicums, limited attention has been given to how different instructional supervision modalities contribute to stress perceptions. As teacher education programmes increasingly use a range of supervision formats, comparative evidence on how on-site, online, and video-based supervision relate to practicum stress within a single practicum context remains scarce. Moreover, much of the existing literature reports stress descriptively, with few studies employing regression analysis to examine factors predicting stress during both teaching and instructional supervision. In addition, teaching-related stress and supervision-related stress are often not modelled as distinct outcomes, despite reflecting different practicum demands. As a result, there is insufficient empirical evidence regarding how supervision methods and contextual factors jointly influence pre-service teachers' stress experiences.

In response to these gaps, the present study seeks to provide a more comprehensive understanding of stress dynamics during the teaching practicum. Specifically, it examines emotional challenges experienced by pre-service teachers, compares stress levels across different instructional supervision methods, and identifies demographic and workload-related factors associated with stress during teaching and instructional supervision. By modelling teaching-related stress and supervision-related stress as distinct outcomes and comparing three supervision modalities within the same practicum context, this study clarifies how supervision format and practicum demands relate to stress experiences. By integrating descriptive analysis with regression modeling, this study contributes empirical evidence to inform practicum design and instructional supervision practices in teacher education. The findings also offer practical implications for teaching programmes seeking to strengthen mentoring and support structures that promote well-being and sustainable entry into the teaching profession.

Guided by these objectives, this study addresses four research questions (RQs). RQ1 examines the emotional challenges experienced by pre-service teachers during their teaching practicum. RQ2 examines whether stress levels differ across instructional supervision methods (on-site, online, and video-based). RQ3 examines which factors significantly predict stress during teaching. Lastly, RQ4 examines which factors significantly predict stress during instructional supervision.

2. METHOD

This study employed a quantitative cross-sectional survey to investigate the emotional challenges and stress experienced by pre-service teachers during their teaching practicum. Data were collected at a single time point during the practicum period. Descriptive statistics were used to summarize emotional experiences and stress levels, while multiple regression analysis was applied to identify factors associated with stress during teaching and instructional supervision.

2.1. Population and sample

The study population comprised 1,250 fourth- and fifth-year students enrolled in the Faculty of Education at Nakhon Ratchasima Rajabhat University, Thailand, during the 2022 academic year. From this population, a sample of 208 pre-service teachers representing 18 majors was selected using convenience sampling, primarily due to access limitations related to practicum placement schedules and institutional coordination across partner schools. This approach supported data collection across multiple disciplines within the faculty.

Although convenience sampling facilitated efficient data collection from multiple disciplines within the faculty, it may limit the generalizability of the findings beyond the specific institutional context. All participants were actively engaged in teaching practicums during the data collection period and were assigned to schools at different educational levels, including early childhood, primary, and secondary education, in accordance with faculty practicum requirements. In addition, the dataset used in this study was previously employed in related research that applied machine learning techniques to cluster stress levels among pre-service teachers [19]; however, the present study addresses different research questions and employs distinct analytical methods focusing on regression analysis.

2.2. Research tools

The primary research instrument used in this study was a structured survey questionnaire designed to collect data on pre-service teachers' practicum experiences and stress levels. The questionnaire consisted of three sections: i) general information covering year of study, gender, and major; ii) current teaching conditions (institution level, workload, and number of subjects taught) and emotional challenges during teaching; and iii) supervision-related stress. In addition, an open-ended question was included to capture further comments or suggestions regarding practicum experiences.

In section 2, teaching-related stress, excitement, and confidence were measured using duration-based scales (0-20) that captured the teaching periods (e.g., 1-3, 4-6, or 7-9 periods) after which these emotional experiences shifted and subsequently stabilized. Responses were converted into a continuous score (possible range: 0-20) using the midpoints of each range, with higher scores indicating a longer duration before adaptation as in Table 1. Negative emotions during teaching (anger, anxiety, frustration, and sadness) were assessed using binary indicators (0=absence, 1=presence) as in Table 2, and supervision-related stress in section 3 was measured using a 5-point Likert scale (1=lowest, 5=highest) across three modalities: on-site, online, and video-based as in Table 3.

Table 1. Emotional challenges of pre-service teachers

Teaching periods	Stress		Excitement		Confidence	
	n	%	n	%	n	%
No such emotion	8	3.85	18	8.65	0	0.00
Teaching one subject						
- After teaching 1-3 periods	17	8.17	54	25.96	54	25.96
- After teaching 4-6 periods	62	29.81	40	19.23	46	22.12
- After teaching 7-9 periods	29	13.94	2	0.96	20	9.62
- After teaching 10-12 periods	0	0.00	0	0.00	0	0.00
- After teaching more than 12 periods	0	0.00	0	0.00	0	0.00
Teaching multiple subjects						
- After teaching 1-3 periods of all subjects combined	0	0.00	41	19.71	25	12.02
- After teaching 4-6 periods of all subjects combined	24	11.54	21	10.10	26	12.50
- After teaching 7-9 periods of all subjects combined	16	7.69	3	1.44	12	5.77
- After teaching 10-12 periods of all subjects combined	0	0.00	0	0.00	4	1.92
- After teaching more than 12 periods of all subjects combined	0	0.00	0	0.00	0	0.00
- After teaching 1-3 periods of each subject	19	9.13	9	4.33	13	6.25
- After teaching 4-6 periods of each subject	10	4.81	0	0.00	2	0.96
- After teaching 7-9 periods of each subject	0	0.00	0	0.00	4	1.92
- After teaching 10-12 periods of each subject	0	0.00	0	0.00	2	0.96
- After teaching more than 12 periods of each subject	0	0.00	0	0.00	0	0.00
Occurs throughout the semester	23	11.06	20	9.62	0	0.00
Total	208	100.00	208	100.00	208	100.00

Table 2. Negative emotions experienced during teaching

Emotions	Frequency	Percent (%)
Anger	35	16.83
Anxiety	150	72.12
Frustration	110	52.88
Sadness	22	10.58
No negative emotions	54	25.96

Table 3. Comparative analysis of supervision-related stress

Instructional supervision method	n (%) of pre-service teachers by stress levels					M	SD	Rating
	Lowest	Low	Moderate	High	Highest			
On-site	15 (7.21)	23 (11.06)	51 (24.52)	66 (31.73)	53 (25.48)	3.57	1.19	High
Online	45 (21.63)	43 (20.67)	76 (36.54)	32 (15.38)	12 (5.78)	2.63	1.15	Moderate
Video	57 (27.40)	52 (25.00)	47 (22.60)	30 (14.42)	22 (14.42)	2.56	1.31	Moderate

To ensure instrument quality, content validity was evaluated by three experts, yielding an item-objective congruence (IOC) index between 0.67 and 1.00. A pilot test with 30 pre-service teachers was conducted to assess clarity and relevance, with minor revisions made accordingly. The questionnaire demonstrated satisfactory internal consistency. Overall Cronbach's alpha was 0.87, which is above the commonly used 0.70 benchmark for acceptable reliability [20].

2.3. Data analysis

Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to describe participants' emotional challenges and stress levels during teaching. Stress levels associated with different instructional supervision methods were measured using a 5-point Likert scale (1=lowest, 5=highest). For the purposes of this study, mean scores were interpreted as follows: 1.00-1.50=lowest, 1.51-2.50=low, 2.51-3.50=moderate, 3.51-4.50=high, and 4.51-5.00=highest.

Multiple regression analysis was conducted to examine the extent to which demographic characteristics and teaching-related factors predicted stress during teaching and instructional supervision. As this study used cross-sectional survey data, regression coefficients were interpreted as associational relationships rather than causal effects. Key regression assumptions were assessed prior to model estimation, including linearity, independence of errors, normality of residuals, and constant error variance. The constant-variance assumption was evaluated through inspection of residual plots and formal heteroscedasticity diagnostics. When evidence of heteroscedasticity was detected, heteroscedasticity-robust standard errors (HC3) were applied to ensure reliable statistical inference. Heteroscedasticity affects the accuracy of standard error estimates and significance tests but does not bias the estimated regression coefficients themselves. Adjusted R^2 and the Akaike information criterion (AIC) were used to assess model fit. All statistical analyses were conducted using SPSS Version 30.0, with a significance level set at 0.05 to ensure the robustness and reliability of the results. This analytical approach enabled an integrated examination of emotional experiences, supervision-related stress, and predictive factors in the teaching practicum context.

2.4. Variable coding

For regression analysis, categorical variables were coded prior to analysis. Gender was coded as 0=male and 1=female. Year of study was coded as 0=fourth year and 1=fifth year. Year of study was treated as a between-group indicator (fourth year vs. fifth year students), rather than a within-person change over time, and therefore did not represent longitudinal measurement. The number of subjects taught was treated as a continuous variable. Academic majors were grouped into broader disciplinary categories to reduce model complexity and avoid overparameterization. These coding decisions were made to ensure statistical validity and interpretability of regression coefficients.

3. RESULTS AND DISCUSSION

This section reports empirical results based on quantitative data and statistical analyses. The findings are discussed in relation to prior literature to support interpretation and clarity. Overall, the results provide an integrated overview of pre-service teachers' stress experiences during the teaching practicum and offer practical recommendations to strengthen institutional support for well-being and sustainable entry into the teaching profession.

3.1. Participants and demographic characteristics

The participants consisted of 208 pre-service teachers from the Faculty of Education at Nakhon Ratchasima Rajabhat University, comprising 111 fourth-year students (53.37%) and 97 fifth-year students (46.63%), of whom 74.04% were female. They represented 18 majors, with the largest groups enrolled in early childhood education (22.12%) and educational technology and communications (16.83%). Most pre-service teachers taught at the primary education level (58.65%), followed by the secondary (34.62%) and early childhood education levels (6.73%). Regarding teaching responsibilities, the majority were assigned to teach one subject (57.70%), followed by two subjects (26.90%) and three subjects (15.40%). Approximately

half of the pre-service teachers reported teaching eight periods per week (50%), whereas the remaining half taught between nine and twelve periods per week. This workload pattern complies with the standards of the Teachers' Council of Thailand, which stipulate a minimum of eight teaching periods per week for professional practice [22]. These demographic characteristics were used as independent variables in the regression analyses presented in Tables 4 and 5.

Table 4. Multiple regression analysis of variables influencing teaching-related stress

Predictive variables	B	β	Robust standard error	t	p	95% CI for B	
						Lower	Upper
Intercept	3.807	-	3.011	1.264	0.208	-2.130	9.745
Year of study (X_1)	-1.004	-0.098	0.691	-1.452	0.148	-2.367	0.360
Gender (X_2)	-0.101	-0.008	0.854	-0.118	0.906	-1.785	1.582
Major (X_3)	0.090	0.089	0.070	1.290	0.199	-0.048	0.228
Institution level (X_4)	-0.537	-0.057	0.651	-0.825	0.410	-1.820	0.746
Workload (X_5)	0.117	0.032	0.291	0.403	0.687	-0.456	0.690
Number of subjects taught (X_6)	2.081	0.306	0.527	3.949	<0.001***	1.042	3.120

Note: N=208; $R^2=0.125$; adjusted $R^2=0.099$; AIC=1253.074; F (6,201)=4.776; $p<0.001$; robust standard error (HC3): * $p<0.05$, ** $p<0.01$, and *** $p<0.001$.

Table 5. Multiple regression analysis of variables influencing supervision-related stress

Predictive variables	B	β	Robust standard error	t	p	95% CI for B	
						Lower	Upper
Intercept	3.057	-	0.701	4.360	<.001***	1.675	4.440
Year of study (X_1)	-0.342	-0.144	0.175	-1.955	0.052	-0.687	0.003
Gender (X_2)	0.522	0.193	0.206	2.528	0.012*	0.115	0.929
Major (X_3)	0.020	0.089	0.017	1.152	0.251	-0.014	0.053
Institution level (X_4)	-0.146	-0.071	0.150	-0.974	0.331	-0.442	0.150
Workload (X_5)	-0.004	-0.004	0.061	-0.061	0.951	-0.124	0.116
Number of subjects taught (X_6)	0.313	0.196	0.097	3.214	0.002**	0.121	0.504

Note: N=208; $R^2=0.120$; adjusted $R^2=0.094$; AIC=650.807; F (6,201)=4.580; $p<0.001$; robust standard error (HC3): * $p<0.05$, ** $p<0.01$, and *** $p<0.001$.

3.2. Emotional challenges of pre-service teachers

Regarding RQ1, the present study examined three primary emotional challenges experienced by pre-service teachers during their teaching practice: stress, excitement, and confidence. Analyses were conducted separately for participants teaching a single subject and those responsible for multiple subjects to examine differences in emotional adjustment associated with varying teaching responsibilities. The key results are summarized in Table 1, and negative emotions reported during teaching are presented in Table 2.

According to Table 1, most pre-service teachers reported a reduction in stress levels after completing 4-6 teaching periods. Specifically, 29.81% of those teaching a single subject indicated that their stress subsided within this range, whereas 11.54% of those teaching multiple subjects experienced similar improvement. Only 3.85% reported no stress, while 11.06% experienced persistent stress throughout the semester. These comparisons between single-subject and multiple-subject groups, as well as the identification of the persistent stress subgroup, are descriptive in nature; no inferential statistical tests were conducted to examine differences between groups. The categories referring to teaching periods (e.g., 1-3, 4-6, or 7-9 periods) represent participants' retrospective reports of when emotional changes were perceived during the practicum. These categories should therefore be interpreted as exposure-based groupings rather than as longitudinal measurements of emotional change over time.

These findings are consistent with the observations of Ji *et al.* [21], who suggested that pre-service teachers often experience stress due to high student expectations, limited subject knowledge, and insufficient teaching experience. Such challenges are particularly pronounced during the initial stages of teaching when classroom exposure is still limited. Moreover, feelings of unpreparedness in managing classroom behavior and addressing diverse learning needs have also been identified as contributing factors [13]. As highlighted by Nawaz *et al.* [22], elevated stress may undermine teaching effectiveness and negatively affect students' learning outcomes, which may explain why participants experiencing persistent stress in this study could face difficulties sustaining instructional confidence during the practicum. In addition, Lindqvist *et al.* [8] noted that such stress may trigger negative emotions (e.g., anxiety, tension, anger, and frustration) and can escalate into adverse physical and psychological outcomes, such as migraines, burnout, and attrition from the profession.

Importantly, the subgroup reporting persistent stress throughout the semester suggests that repeated classroom exposure alone may be insufficient for some pre-service teachers, underscoring the need for targeted support beyond early practicum adjustment. This pattern indicates that emotional adjustment during

the practicum may depend not only on teaching repetition but also on individual coping capacity and the availability of mentoring support. These results suggest that teacher education programmes should introduce structured emotional support during the early practicum period, including guided reflection sessions and mentor-led discussions on classroom challenges. Such interventions may help pre-service teachers reinterpret stressful teaching experiences as part of professional learning and reduce the likelihood of persistent stress across the semester.

Regarding excitement, 25.96% of pre-service teachers teaching a single subject and 19.71% of those teaching multiple subjects reported a decline in excitement after 1-3 teaching periods. A small number (8.65%) experienced no excitement, whereas 9.62% maintained high levels of excitement throughout the semester. These results align with Lewis [23], who noted that enthusiasm is typically elevated at the beginning of the semester due to the novelty of teaching but tends to stabilize as teachers gain experience. Within this study, excitement was conceptualized as a combination of nervousness, anticipation, and restlessness commonly observed during the early stages of teaching [24].

In contrast, confidence displayed a progressive upward trend. Approximately 25.96% of pre-service teachers teaching a single subject reported increased confidence after completing 1-3 periods, while 12.50% of those teaching multiple subjects exhibited similar growth after 4-6 periods. Confidence is widely recognized as a crucial factor for practical instruction and favorable learning outcomes [25]. As confidence increases, teachers are better able to recognize and address learning challenges, employ effective classroom management strategies, and adopt innovative instructional practices. Similarly, strong teaching commitment is associated with more purposeful lesson planning and sustained engagement in structured professional development [26].

While this overall pattern suggests gradual adjustment during the practicum, the identification of a persistent-stress subgroup complicates this picture. A subset of pre-service teachers continued to report elevated stress despite repeated classroom exposure. This challenges the assumption that practicum stress naturally declines with experience and indicates that adaptation is not uniform across individuals.

In light of this divergence in adjustment patterns, the findings of this study demonstrate the necessity of institutional support in facilitating pre-service teachers' effective participation in their teaching practicum. In line with the observed early adjustment pattern and the subgroup experiencing persistent stress, institutions may strengthen support through structured preparation and mentoring that prioritise classroom management and emotion regulation, complemented by practical stress-management strategies (e.g., mindfulness or brief coping routines) [13], [27], [28]. Such support can be delivered through guided reflection and mentoring discussions to help pre-service teachers interpret emotionally challenging experiences as part of learning to teach and to reinforce confidence during instruction [25]. In addition, institutions should consider limiting the number of subjects assigned to pre-service teachers, as the study indicates that broader teaching responsibilities are associated with higher stress, even when overall workloads remain within standard requirements.

According to Table 2, 25.96% of pre-service teachers reported not experiencing any negative emotions while teaching, indicating that the remaining pre-service teachers (74.04%) experienced at least one negative emotion during their teaching practice. Anxiety was the most prevalent (72.12%), which may stem from challenges such as managing student misbehavior, perceived lack of recognition for teaching efforts, and pressure to deliver engaging and creative lessons [27]. Frustration was the second most frequently reported emotion (52.88%), followed by anger (16.83%) and sadness (10.58%).

The presence of negative emotions has been shown to substantially impair teaching effectiveness by narrowing teachers' cognitive focus and limiting their ability to engage deeply with instructional tasks. When such emotions become overwhelming, self-control often diminishes, leading to undesirable behaviors toward students, reduced patience, and emotional disengagement. These patterns can consequently weaken the overall quality of teacher-student relationships [29]. This is consistent with Liu's findings [30], which suggest that negative emotions may also serve as informative signals, prompting pre-service teachers to reflect on emerging professional limits. Teacher education programmes may therefore benefit from providing structured opportunities, such as guided reflection and mentoring discussions, to help pre-service teachers make sense of emotionally challenging practicum experiences and support more sustainable professional development. Taken together, the high prevalence of anxiety and frustration suggests that emotional demands are a central feature of practicum experience, and such structured reflection and mentoring may be especially important for supporting coping and professional boundary development.

3.3. Stress from instructional supervision by the supervising teachers

For RQ2, during the teaching practicum, pre-service teachers are evaluated through instructional supervision conducted by supervising teachers. This process focuses on assessing teaching performance, providing constructive feedback to improve instructional quality, and monitoring professional conduct. It also

includes evaluating related components such as classroom research and report writing. Instructional supervision is implemented through three methods: i) on-site supervision, where pre-service teachers are observed and assessed directly at the school; ii) online supervision, in which teaching performance is evaluated in virtual classrooms using platforms such as Zoom, Google Meet, or Microsoft Teams; and iii) video-based supervision, where teaching effectiveness is reviewed through recorded clips of on-site or online lessons.

Pre-service teachers reported varying levels of stress across the three instructional supervision methods. To examine these differences, supervision-related stress was compared across on-site, online, and video-based supervision. The comparative results are summarized in Table 3. According to the table, pre-service teachers reported the highest stress levels during on-site instructional supervision ($M=3.57$, $SD=1.19$), followed by online supervision ($M=2.63$, $SD=1.15$) and video-based supervision ($M=2.56$, $SD=1.31$). The on-site supervision method showed a pronounced concentration in the higher stress levels, with high (31.73%) and highest (25.48%), while comparatively fewer participants reported lowest (7.21%) or low (11.06%). By contrast, online supervision showed greater clustering at moderate (36.54%) and a smaller proportion at highest (5.78%). Video-based supervision demonstrated a similar pattern of moderate overall stress, with relatively more responses at the lower end, including lowest (27.40%) and low (25.00%), as well as high (14.42%) and highest (14.42%).

Repeated measures analysis of variance ANOVA showed a significant difference in supervision-related stress across the three methods. Mauchly's test indicated that the sphericity assumption was violated ($p<0.001$); therefore, Greenhouse-Geisser corrections were applied ($\epsilon=0.914$). The effect of supervision method was significant, $F(1.83, 378.40)=59.88$, $p<0.001$, $\eta^2=0.126$. Post hoc pairwise comparisons with Holm adjustment indicated that on-site supervision produced significantly higher stress than online (mean difference=0.942, $p<0.001$) and video-based supervision (mean difference=1.014, $p<0.001$), while the difference between online and video-based supervision was not significant (mean difference=0.072, $p=0.464$).

Stress associated with instructional supervision varied across supervision modalities, with on-site supervision producing the highest stress levels. This finding suggests that direct observation and immediate evaluation intensify performance pressure among pre-service teachers. In contrast, online and video-based supervision were associated with lower stress, potentially due to reduced immediacy and greater perceived control over teaching performance. These results suggest that teacher education programmes may benefit from adopting hybrid supervision structures that combine on-site, online, and video-based approaches. Such models may reduce performance pressure during early practicum stages while maintaining opportunities for observation and feedback, thereby supporting both instructional development and emotional adjustment among pre-service teachers.

Stress associated with on-site supervision primarily arises from direct observation and immediate performance evaluation by supervising teachers. Many pre-service teachers feel tense and self-conscious when teaching in front of evaluators, reflecting performance anxiety or stage fear. These reactions may include forgetting lesson content, speaking hesitantly, and physiological responses such as increased heart rate, sweating, and a perceived loss of self-control [31]. Stress may intensify when pre-service teachers perceive themselves as inadequately prepared to teach [13]. Consistent with Yetkin and Alagözölü [32], observation and monitoring by mentor teachers and supervisors can heighten pre-service teachers' nervousness and anxiety, potentially undermining their confidence and teaching performance.

Taken together with the patterns observed across supervision formats, the present study offers comparative evidence by examining three supervision modalities within the same practicum cohort. Unlike prior research that typically focused on a single format or pandemic-specific online contexts, this study identifies systematic differences in stress patterns associated with supervision format. The finding that on-site supervision produces substantially higher stress levels, even under comparable workload conditions, supports the interpretation that supervision format itself may relate to differences in perceived stress intensity.

In contrast, stress during online supervision was generally lower but often linked to technical problems such as unstable internet connections, device limitations, and disruptions from students during online sessions. Nervousness and reduced focus were common, particularly when teachers had to manage digital tools while teaching. These findings align with Özüdoğru [33], who reported that online teaching commonly involves technological and connectivity constraints that can disrupt instruction. They are also consistent with Geesa *et al.* [34], who highlighted that pre-service teachers may experience frustration due to technical failures beyond their control, additional pressure to explain technology use to students with varying digital readiness, and limited training in real-time troubleshooting during online lessons.

Video-based supervision was perceived as the least stressful. This may occur because asynchronous evaluation reduces immediate performance pressure and allows pre-service teachers to focus more on instructional delivery rather than real-time observation. Although some participants expressed concern about recording errors or self-consciousness on camera, many indicated feeling more relaxed when not under direct observation. This finding corresponds with Özüdoğru [33], who reported that asynchronous video evaluations

allowed pre-service teachers to perform more comfortably and confidently, free from real-time performance pressure.

The findings suggest that educational institutions adopt flexible instructional supervision options that combine online and video-based approaches to reduce stress among pre-service teachers and expand access to effective supervision, particularly when supervisors are unable to travel to practicum sites. These approaches can support classroom observation, timely feedback, and mentoring through both synchronous and asynchronous formats. Supportive supervision and institutional mentoring may also strengthen pre-service teachers' confidence, emotional resilience, and instructional competence [25], [29]. In addition, our earlier analysis of the same dataset using machine-learning clustering identified distinct stress profiles, including a smaller subgroup experiencing high stress, further highlighting the need for flexible and targeted support for pre-service teachers at greater risk [19].

3.4. Factors influencing stress among pre-service teachers

Teaching-related stress, operationalized as the duration of stress before adaptation, was calculated using the midpoints of teaching periods (possible range: 0-20). The observed mean score was 7.13 (SD=5.07). For supervision-related stress, although the survey collected responses across three modalities (on-site, online, and video), the regression analysis focused on on-site supervision because all participants (100%) experienced this modality in practice. In contrast, responses for online and video supervision did not fully capture participants' actual supervisory experience. The observed mean for on-site supervision stress was 3.57 (SD=1.19), indicating a high level of perceived stress.

This section presents an analysis of the factors associated with stress among pre-service teachers during their professional teaching practicum. With respect to RQ3 and RQ4, multiple regression analysis was conducted to examine six independent variables, namely year of study (X_1), gender (X_2), major (X_3), institution level (X_4), workload (X_5), and number of subjects taught (X_6). Multicollinearity was assessed prior to the analysis, and the variance inflation factors (VIFs) ranged from 1.06 to 1.28, indicating no multicollinearity concerns. This multivariate approach aims to pinpoint the critical predictors associated with stress during teaching and stress arising from instructional supervision, with the detailed results summarized in Tables 4 and 5.

According to Table 4, the regression analysis showed that only the number of subjects taught (X_6) had a statistically significant positive association with teaching-related stress ($B=2.081$, 95% CI [1.042, 3.120], $\beta=0.306$, $t=3.949$, $p<0.001$). This finding indicates that a higher number of subjects taught was associated with higher levels of teaching-related stress, with an estimated increase of approximately 2.08 points in the stress score for each additional subject taught while other variables were held constant. The remaining predictors, including year of study, gender, major, institution level, and workload, did not show statistically significant relationships with teaching-related stress. The regression model was statistically significant ($F(6,201)=4.776$, $p<0.001$) and explained 9.9 percent of the variance in stress levels (adjusted $R^2=0.099$). Although the model was statistically significant, the explained variance was modest, suggesting that other contextual or psychological variables not captured in this study may also influence teaching-related stress levels. As this study used cross-sectional survey data, regression coefficients are interpreted as associational relationships rather than causal effects. The predictive equation for stress during teaching is expressed as (1):

$$Y' = 3.807 - 1.004X_1 - 0.101X_2 + 0.090X_3 - 0.537X_4 + 0.117X_5 + 2.081X_6 \quad (1)$$

These findings are consistent with the results of Agyapong *et al.* [16], who identified multiple factors contributing to stress, burnout, anxiety, and depression among educators, including demographic characteristics such as gender, age, and marital status, as well as organizational aspects such as teaching experience, class size, job satisfaction, and subject area. Similarly, Deaton *et al.* [35] reported that teachers with heavy workloads, including those teaching several subjects, supporting students with mental health problems, and lacking sufficient institutional resources, tend to experience greater stress and higher attrition rates. In addition, Zhang *et al.* [36] found that teaching multiple subjects is associated with increased demands on lesson preparation, activity design, and assessment, all of which may contribute to higher stress levels.

Table 5 summarizes the multiple regression results for supervision-related stress. Gender (X_2) and the number of subjects taught (X_6) were significant predictors of supervision-related stress, while year of study (X_1), major (X_3), institution level (X_4), and workload (X_5) were not significantly related. The overall model was significant ($F(6,201)=4.580$, $p<0.001$) and explained 9.4 percent of the variance in stress levels (adjusted $R^2=0.094$). Although the model was statistically significant, the explained variance was modest, suggesting that other contextual or psychological variables not captured in this study may also influence stress levels during instructional supervision. Consistent with the cross-sectional design described above, these results are interpreted as associations rather than causal effects.

This equation summarizes the estimated contribution of each predictor while holding the other variables constant. It is provided to support transparency and facilitate interpretation of the model results. The predictive equation for supervision-related stress, based on the regression coefficients in Table 5, is:

$$Y' = 3.057 - 0.342X_1 + 0.522X_2 + 0.020X_3 - 0.146X_4 - 0.004X_5 + 0.313X_6 \quad (2)$$

The results indicated that gender (X_2) was also significantly associated with stress, with female pre-service teachers reporting 0.522 points higher stress than male teachers ($B=0.522$, 95% CI [0.115, 0.929], $\beta=0.193$, $t=2.528$, $p=0.012$). This pattern is consistent with Gilar-Corbi *et al.* [17], who found that female pre-service teachers reported higher levels of academic- and work-related stress than male pre-service teachers, and with Putri *et al.* [37], who likewise reported gender differences in teaching-related stress and anxiety among pre-service teachers. Finally, the number of subjects taught (X_6) showed a positive relationship with stress ($B=0.313$, 95% CI [0.121, 0.504], $\beta=0.196$, $t=3.214$, $p=0.002$), indicating that teaching additional subjects is associated with higher stress levels. This finding aligns with previous research identifying heavy workload, lesson planning, and supervision-related demands as important sources of stress among pre-service teachers during the teaching practicum [12], [38]. These results highlight the importance of carefully assigning teaching responsibilities during the practicum, particularly by managing the number of subjects allocated to student teachers. Reducing the number of subjects assigned may help alleviate the burden of lesson preparation and allow greater focus on instructional quality and classroom management.

Beyond the individual predictor effects, the analytical approach adopted in this study offers an additional contribution. By modelling teaching-related stress and supervision-related stress as distinct outcomes, differential predictor patterns across practicum domains become visible. While the number of subjects taught predicted both forms of stress, gender was associated specifically with supervision-related stress. These distinctions would likely have remained obscured if stress had been treated as a single undifferentiated construct.

3.5. Limitations

This study has several limitations. First, the use of convenience sampling from a single institution may restrict the generalizability of the findings to other teacher education contexts. Second, data were collected using self-report measures, which may be subject to response bias. Third, the regression models explained a relatively small proportion of variance in stress levels, indicating that additional factors, such as mentor support, school climate, or prior teaching experience, may also influence pre-service teachers' stress. Finally, the cross-sectional design of the study does not allow for causal inferences. These limitations point to several directions for future inquiry.

3.6. Future research

Future research should focus on developing the potential of real-time data analytics and artificial intelligence (AI) to support effective teaching supervision, using empirical data to generate recommendations relevant to individual contexts. Such systems could analyze stress levels from pre-service teachers' voices or self-reflection messages, or use wearable devices to track physiological signals, such as heart rate, stress, and emotions, during teaching, so that teachers receive important information promptly. In parallel, data streams from technology-enhanced teaching platforms can be processed in real time to generate target recommendations that optimize instructional moves, including adjustments to interaction patterns, timing, and scaffolding for pre-service teachers during lessons. This technology approach will enable proactive stress management, and integrating these tools into the teaching internship process will promote a flexible learning environment conducive to sustainable teacher development in the future.

4. CONCLUSION

Taken together, the findings extend existing research by providing comparative evidence across supervision modalities, differentiating between teaching-related and supervision-related stress, and identifying a persistent-stress subgroup. The findings highlight how practicum demands are associated with different instructional and evaluative contexts. The results demonstrate that stress experiences are shaped not only by workload but also by supervision format and developmental stage.

Stress and emotional challenges are prevalent among pre-service teachers during the teaching practicum, particularly when teaching multiple subjects and undergoing on-site instructional supervision. While these stressors may affect well-being and professional development, they should be interpreted as occupational and educational challenges rather than clinical conditions. These findings underscore the importance of timely mentoring and emotional support during the practicum.

Educational institutions are encouraged to design practicum structures that balance instructional demands with emotional well-being. Managing the number of subjects assigned and incorporating flexible supervision formats may help reduce stress during the practicum. Strengthening mentoring systems may contribute to more sustainable teacher development and smoother professional transition during the early stages of teaching careers.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : Conceptualization

M : Methodology

So : Software

Va : Validation

Fo : Formal analysis

I : Investigation

R : Resources

D : Data Curation

O : Writing - Original Draft

E : Writing - Review & Editing

Vi : Visualization

Su : Supervision

P : Project administration

Fu : Funding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

This study received ethical approval from the Naresuan University-Network of Research Ethics Committee (NU-NREC) on February 8, 2023 (COA No. 0044/2022; NREC No. 0055/2565). NU-NREC is responsible for reviewing research involving human participants to ensure that study procedures comply with the University's ethical standards and applicable regulations.

DATA AVAILABILITY

The data from this study are available from the corresponding author, [SN], upon reasonable request. Access to the data may be subject to confidentiality agreements or ethical restrictions.

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