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In-Service Teachers' Engagement in Online Professional Learning: Between Compliance and Commitment

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Abstract: This study aims to identify teachers' engagement patterns in an online professional teacher education program (Program Profesi Guru) and differentiate compliance-based engagement from commitment-based engagement. An exploratory quantitative approach was employed, complemented by individual-level analysis using K-Means clustering. A total of 200 in-service teachers participated in this study. The instruments were adapted from Reeve and Tseng's multidimensional engagement framework, which includes agentic, behavioral, emotional, and cognitive engagement. The findings reveal three distinct clusters of engagement: (1) High Engagement, (2) Moderate–Passive Engagement, and (3) Low Engagement. Among these clusters, agentic engagement serves as the key distinguishing factor separating genuine commitment-based engagement from formalistic compliance-based participation. These results underscore the need for adaptive techno-pedagogical designs that provide profile-specific opportunities for initiative, choice-making, and learner-directed participation. Overall, this study offers empirical insights for developing online teacher training that is more reflective and oriented toward strengthening professional agency.

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Introduction

Global teacher education has shifted into online or hybrid formats. It has become essential in recent years due to technological progress (Bedoya-flores & Lara-tambaco, 2023; Irish et al., 2023). There is a need to develop a more flexible and accessible education system. This shift is not just a change in how teaching is delivered; it represents a fundamental evolution in how teachers are professionally trained and grow to fulfil their teaching roles (Neupane, 2020). Online and hybrid options provide the opportunity to personalize learning, where the content and teaching methods cater to the individual needs of teachers.

Technology plays a key role in this digital transformation, where teachers are required to operate various tools and digital platforms while effectively integrating them into their teaching and learning(Wohlfart & Wagner, 2025). Teachers can use applications and online learning platforms to deliver material interactively, utilize social media for sharing educational resources, and even employ data analysis to monitor students' progress in real time (Alptekin, 2025; Khan et al., 2021). Therefore, this transformation demands a paradigm shift in educational management, from leadership strategies and curriculum development to evaluation methods.

Although technology offers many opportunities, the shift to online and hybrid models introduces its own challenges. The digital divide, teachers' lack of digital skills, and privacy

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and security concerns are primary obstacles that must be addressed(Martin et al., 2023; Tang et al., 2024). Therefore, a comprehensive approach is necessary to incorporate technological aspects, enhance human resources' skills, and redesign the educational process to create flexible, high-quality learning environments(Magalhães et al., 2024). Ongoing professional development for teachers is a crucial element in preparing them to meet educational challenges in this digital age.

Despite the widespread access provided by technological advancements across various learning platforms, teachers' engagement in online professional development remains superficial (M. Chen et al., 2023; Prestridge & Tondeur, 2015; Truong & Murray, 2020). This creates a significant obstacle to educational transformation. Effective engagement is more than just being present and completing assignments; it is a multidimensional concept that demands deep mental investment from individuals (Reeve & Tseng, 2011). They specifically clarify that learning engagement includes four dimensions: behavioral, cognitive, emotional, and agentic engagement. Teachers should actively and constructively contribute to shaping their learning experiences. Therefore, to improve engagement, it is crucial to understand that it results from dynamic interactions among these four dimensions, meaning it requires more than passive participation in online training.

The unique challenge in the Teacher Education Program (Pendidikan Profesi Guru or PPG hereafter) in Indonesia is the significant administrative pressure. This issue risks causing participants to focus on compliance-based engagement, where the main aim shifts from meaningful learning to simply fulfilling formal requirements (Baharuddin & Burhan, 2025; Hidayati et al., 2023). Such engagement occurs when teachers prioritize completing tasks, uploading physical proof, and meeting deadlines over understanding concepts and reflecting deeply on their teaching practices. Studies on in-service teachers in the PPG in Indonesia show that participants are overwhelmed with numerous administrative assignments on the Learning Management System with tight deadlines, making their interaction with the material superficial because they see it as just fulfilling requirements (Tri Murdiyanto, 2020). This situation aligns with the high workload in online teacher education programs, which mainly involve procedural assignments like writing reports and portfolios. This heavy workload can lead to teacher burnout and cause teachers to focus less on developing essential pedagogical skills. As a result, this pressure shifts the program's focus from genuine professional growth to simply completing tasks, ultimately reducing the program's effectiveness in preparing transformative teachers.

Previous research on learning engagement has primarily focused on students, while teachers' engagement in their own learning has not been thoroughly explored, especially within the context of certification-based education(Bergdahl, 2022; Chiu, 2021; Errabo, 2024; Wei et al., 2023). Few studies have been conducted on teachers' engagement, leaving it unclear whether their motivation to learn is driven by administrative demands or by their intrinsic dedication to professional growth. Additionally, exploratory quantitative methods like cluster analysis to identify segments of teachers' engagement are rarely utilized. However, this approach could potentially provide a deeper understanding of how teachers engage in online training. Given these gaps, this study aims to identify teachers' engagement patterns in their online PPG and differentiate between compliance-based and commitment-based engagement.

Understanding teachers' engagement patterns enhances the theoretical understanding of professional engagement, particularly in online teacher training(M. Chen et al., 2023; Fütterer et al., 2024). By providing a solid empirical foundation, this study's results can help develop more relevant, effective, and responsive training programs that meet participants'

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needs. Additionally, analyzing teachers' engagement profiles will support more tailored and targeted interventions, allowing training to be adapted to the different characteristics and motivations of various participant groups.

The multidimensional learning engagement framework offers a comprehensive theoretical view of how people engage in learning by identifying four interconnected but distinct dimensions (Reeve & Tseng, 2011). This framework extends beyond the traditional approach, which assesses participation by dividing learning engagement into four main components: behavior, cognitive, emotional, and agentic.

Teachers' involvement in professional development significantly affects learning quality and effectiveness(Fütterer et al., 2024). When teachers show high engagement—whether behavioral, cognitive, emotional, or agentic—they tend to reflect on their teaching methods and adopt new strategies. They are also more likely to implement their knowledge in the classroom. A teacher who is engaged agentically will seek out additional resources beyond their training materials (Khabar et al., n.d.). Additionally, they will discuss ideas with peers, which ultimately enhances their learning process. Conversely, low engagement or engagement focused mainly on administration reduces training to a mere formality without a meaningful impact on teaching quality. Therefore, understanding and promoting genuine engagement is essential for creating effective teacher training.

Behavioral engagement refers to active participation and effort in academic tasks, such as completing and submitting assignments on time and following rules (Wang et al., 2019). Behavioral engagement in the teacher PPG context often reflects compliance with administrative requirements rather than true engagement. This conflicts with the idea of deep learning. Ideally, this dimension assesses active participation, effort, and perseverance in learning; however, in practice, it has shifted to simply completing procedural tasks to meet requirements.

Another aspect of learning engagement is cognitive engagement. It plays a crucial role in learning as individuals actively process, understand, and synthesize new information (Reeve & Tseng, 2011). When teachers are cognitively involved, they connect their prior knowledge, analyze concepts critically, and practice higher-order thinking skills. In the context of online PPG, teachers who exhibit cognitive engagement assess the effectiveness of the learning methods they learn, compare them to their classroom practices, and develop new approaches tailored to students' needs. This kind of engagement not only enhances their understanding but also bolsters their reflective and adaptive skills in tackling learning challenges.

Emotional engagement is another crucial aspect of learning because it reflects the affective bond individuals have with the learning process, material, and environment(Matos et al., 2018; Reeve, 2012). When teachers are excited, motivated, and feel a sense of belonging to the training they are part of, they tend to be more open to change and persistent in facing challenges. Positive emotions like confidence and satisfaction with the training material can enhance their focus on learning(Hernández-Barco et al., 2024; Qi et al., 2025). Conversely, negative emotions such as anxiety and dissatisfaction may disrupt their information processing and reduce learning effectiveness.

The impact of emotional engagement on learning achievement is significant (Qi et al., 2025), especially in professional training contexts like online PPG. Emotionally engaged teachers may find it easier to connect training material with their teaching practices. It also enables them to apply their learning sustainably. Teachers who feel proud and satisfied after completing training modules are more motivated to adopt new classroom methods and share their experiences with peers (Windasari et al., 2025). Therefore, designing a training

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environment that promotes emotional engagement is key to increasing the effectiveness and long-term impact of training programs.

Agentic engagement is vital in learning because it shows the active participation of teachers in influencing and shaping their learning experience. Teachers with agentic engagement typically contribute actively by asking questions, providing feedback, and seeking additional resources to improve their understanding. In the context of online PPG, teachers with agentic engagement usually use the discussion forum to share their experiences, ask for clarification on anything they do not understand, or even suggest additional topics relevant to their classroom context. This engagement not only improves individuals' learning quality but also enriches the dynamics of collective learning in the training program. Previous studies on PPG in the Indonesian context show that what motivates teachers to participate in the program are intrinsic factors, including their career and economic reasons, as they will receive certification once they complete the program (Karnadi & Istiyani, 2024; Siahaan et al., 2023). They still focus on perceived satisfaction (Siahaan et al., 2023; Wati et al., 2022).

Compliance vs Commitment in Professional Engagement

A framework for learning engagement can differentiate between compliance and commitment, each reflecting extrinsic and intrinsic motivation. Compliance involves engagement driven by system requirements, incentives, or administrative obligations, such as participating in training for certification or institutional mandates (Hoskin, 2025; Proudfoot & Boyd, 2025). In contrast, commitment reflects intrinsic motivation and autonomy, where individuals engage because they personally want to improve and enhance teaching quality (S. Chen & Rani, 2025; Jankelová et al., 2025). For example, a teacher who joins the PPG program because he wants to gain a deeper understanding of pedagogy and apply his knowledge in the classroom demonstrates commitment. Meanwhile, a teacher who participates in the program because it is mandatory by the educational institution shows compliance. This distinction is important because commitment engagement often leads to more meaningful and sustainable learning.

Compliance-based engagement may appear to be active, but it is often not accompanied by emotional involvement and deep reflection (Diamond & Bulfin, 2025). In teacher training, participants might seem diligent in following the schedule, completing assignments, and participating in online sessions. However, their motivation is usually driven by administrative requirements (Lee et al., 2001) or certification rather than an intrinsic desire to learn. As a result, while learning activities occur, the meaning-making of the material and its implementation in teaching practice can be superficial. Teachers who participate in PPG out of obligation might complete all the modules on time, but they may not reflect on how the strategies learned can be applied in their specific classroom contexts. This shows that active behavior does not always equate to meaningful engagement in learning.

Cluster mapping is highly relevant for identifying the orientation of participant engagement, as it can group individuals based on similar engagement patterns (Pastor, 2010). Using a quantitative approach such as cluster analysis, this study can identify teacher segments who demonstrate compliance-based engagement, active behavior with minimal reflective practice, and distinguish them from teachers who display commitment-based engagement. Cluster analysis enables the identification of groups of teachers who complete all assignments but rarely participate in discussions, and others who actively participate, evaluate materials, and show high enthusiasm for classroom practices (ibid). These findings are useful in designing teacher interventions that target specific groups and improve the overall quality of training. Recognising the difference between compliance and genuine

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commitment allows researchers to more fully grasp the lived realities of teachers' professional engagement, offering evidence that can guide the development of programs that nurture meaningful, lasting growth rather than routine participation only. This study extends prior research by distinguishing routine, compliance-based participation from authentic commitment through a multidimensional framework of student engagement. By applying cluster analysis to these dimensions, the study identifies evidence-based engagement profiles that have not been systematically documented in earlier work.

This study aims to develop a clearer picture of how teachers participate in online PPG programs by examining their engagement across agentic, behavioral, emotional, and cognitive dimensions. In doing so, it seeks to identify whether distinct patterns of learning emerge among participants and to understand what these patterns reveal about the nature of their involvement, whether it reflects a sincere professional commitment or is shaped more by administrative expectations.

Research Method

This research employs an exploratory quantitative design with a person-centered approach to identify teachers' engagement patterns in online PPG learning. The approach allows the analysis to focus on individual characteristics holistically (Creswell & Creswell, 2017), revealing distinct segments of teachers with similar engagement patterns. Using cluster analysis, engagement data, including emotional, cognitive, behavioral, and agentic elements, will be examined to identify distinct patterns that, in turn, will be used to form groups of participants with different engagement orientations, whether compliance or commitment. It will be analysed to form groups of participants with varying orientations of engagement, whether compliance or commitment. This design is relevant for understanding the complexity of teachers' motivation and participation in training and sets the foundation for developing interventions that are better tailored to specific needs.

This study's population includes in-service teachers participating in online PPG. It employs random sampling to ensure that each unit in the population has equivalent opportunities to be chosen so that the variance structure for clustering in K-means is objectively represented. There are 200 teachers taking part in this study. The instrument used in this study is adapted from Reeve & Tseng (2011). It uses a 5-point Likert scale that ranges from 1 (strongly disagree), indicating complete rejection of the statement, to 5 (strongly agree), reflecting full endorsement, with intermediate points of 2 (disagree), 3 (neutral), and 4 (agree) representing progressively stronger levels of alignment with the statement. The instruments consist of items representing the four dimensions of engagement: behavioural, cognitive, emotional, and agentic.

Data collection was conducted using a Google Form and shared with all participants. Initially, teachers received informed consent forms explaining the study's purpose, data confidentiality, and their right to participate voluntarily. Only those who gave consent could proceed to complete the questionnaire. After data collection was completed, all data were processed and analyzed statistically with Jamovi.

The data analysis involved two stages: pre-analysis and main analysis. The pre-analysis stage aimed to ensure the quality of the data used in this study. The first step was checking for missing values and identifying extreme values that could disrupt the analysis results. The second step was conducting an internal reliability test using Cronbach's Alpha to evaluate the consistency between items in the instruments.

The main analysis stage involved descriptive statistics, including the mean and standard deviation for each engagement dimension. The scores were then standardized using

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z-score conversion in preparation for cluster analysis. K-Means clustering was performed to group respondents into 2-4 clusters. The optimal number of clusters was determined based on the elbow method and a substantial interpretation of the engagement patterns. Once the clusters were identified, difference analyses among the clusters were conducted using ANOVA or Kruskal-Wallis tests on the engagement score. If significant differences were found, post-hoc tests were performed. The final stage involved interpreting each cluster and labeling them based on the engagement dimensions: cognitive-agentic, behavioral-low emotional, and mapping them to determine whether they were oriented toward compliance or commitment.

Results and Discussion

The analysis started with descriptive statistics showing high scores for teachers' engagement, although a low score indicated a moderate outlier. The reliability test ensured the internal consistency of the instrument, while the z-score standardization balanced the scales across the dimensions. Next, K-means analysis was used to explore the cluster patterns, comparing 2- and 3-cluster models in terms of simplicity and interpretability. The final interpretation uncovers engagement profiles that reflect the dynamics of compliance and commitment in teachers' professional learning.

The descriptive statistics (see Table 1) analysis of the four constructs showed that most respondents gave high scores, as indicated by mean values approaching the maximum: Behavioral Engagement (mean = 4.82), Emotional Engagement (mean = 4.69), Cognitive Engagement (mean = 4.55), and Agentic Engagement (mean = 4.04). The high median values (5.00 for BE and EE constructs) reinforce this finding, indicating that more than half of the respondents assigned the maximum score. However, the data revealed moderate outliers, evidenced by low minimum values such as 2.80 for Behavioral Engagement and 1.00 for Agentic Engagement. The negative skewness value, especially for behavioral engagement (-90), demonstrated that the distribution leaned to the right, with high scores dominating but a few extremely low values. Additionally, the high kurtosis value for behavioral engagement indicated that the distribution was sharp and potentially contained outliers.

Table 1. Descriptive Statistic

	BE	**EE**	**CE**	**AE**
Mean	4.82	4.69	4.55	4.04
Median	5	5	4.75	4
Standard deviation	0.368	0.493	0.492	0.749
Skewness	-2.9	-1.75	-1.28	-0.822
Kurtosis	10.3	2.84	1.41	0.849

Outlier detection revealed respondents with extreme values that potentially affected the data distribution. Based on the boxplot and z-score calculation with a cut-off of ±3, it was identified that one respondent had an extremely low score on three constructs: agentic engagement (1.0), cognitive engagement (2.75), and behavioral engagement (2.8). These scores were below the average and median of each construct and showed a significant deviation from the common pattern. Nevertheless, this outlier was retained in the analysis as part of the natural variance in the population, not as a measurement error or incorrect data input. The reliability analysis showed that all the items of each engagement dimension were 0.95, as shown in Table 2.

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Table 2. Scale Reliability Statistics

Mean	Cronbach's α
4.52	0.95

For the cluster analysis, all engagement dimensions were standardized into Z-scores (Table 3) so that each dimension was on the same scale. The Z-score distribution indicated variability; for example, the Behavioral Engagement Z-score had a skewness of -2.99 and kurtosis of 10.3, while the Agentic Engagement Z score showed a skewness of -0.822 and kurtosis of 0.849, suggesting deviations from a normal distribution.

Table 3. Z-Score

	BE_Z	EE_Z	CE_Z	AE_Z
N	221	220	220	220
Mean	5.65	4.69	3.67	-5.00
Median	0.502	5	0.407	-0.059
Standard deviation	1	0.493	1	1
Skewness	-2.9	-1.75	-1.28	-0.822
Kurtosis	10.3	2.84	1.41	0.849

K-Means analysis (See Table 4) resulted in two clusters used to identify patterns of teachers' engagement in their online professional learning. The two-cluster model divided respondents into a large group (Cluster 2, n=177) and a smaller group of 40 respondents, with a centroid indicating significant differences. Cluster 1 had low scores across all dimensions (*BE_Z* = −1.521, *EE_Z* = −1.731, *CE_Z* = −1.617, *AE_Z* = −0.931), while Cluster 2 showed a more balanced distribution. Cluster 3 indicated a moderate positive score. Although simple, the model revealed an unbalanced distribution and did not capture the complexity of engagement.

On the other hand, the 3-cluster model showed a more balanced distribution (cluster 1 =96, cluster 2 = 38, and cluster 3 = 83) with a more meaningful pattern. Cluster 2 depicted low engagement (BE_Z = −1.598, AE_Z = −0.956), while cluster 2 indicated high engagement (BE_Z = 0.392, AE_Z = 0.829), and cluster 3 represented moderate yet passive engagement (BE_Z = 0.278, AE_Z = −0.521). The between-cluster sum of squares increased from 431 in the two-cluster model to 532.7 in the three-cluster model, demonstrating better separation and a more informative cluster structure.

Table 4 . K-Means Analysis Result

Model	Cluster	Number	BE_Z	EE_Z	CE_Z	AE_Z
2 Cluster	1	40	-1.521	−1.731	−1.617	−0.931
	2	177	0.344	0.391	0.365	0.21
3 Cluster	1	96	0.392	0.536	0.64	0.829
	2	38	−1.598	−1.762	−1.650	−0.956
	3	83	0.278	0.187	0.015	−0.521

Findings of this study emphasise that teachers' engagement in online professional daring is not uniform; it is distributed into different patterns. In general, their engagement level is in the high category, but the fact that there is a respondent with an extremely low score indicates a significant variance in learning experiences. Cluster analysis showed that a three-cluster model is the most representative, resulting in *High Engagement, Low Engagement, and Moderate but Passive Engagement profiles*. These three profiles reflect a more complex dynamic rather than just distinguishing high and low engagement. They demonstrate the importance of the agentic engagement dimension, which differentiates

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proactive participation from mere compliance. These findings provide evidence of heterogeneity in teachers' engagement patterns within the context of online professional learning.

The engagement level of the respondent in this online teacher professional education reveals interesting findings about motivation variety and individual obstacles. Most of the respondents demonstrate a high level of engagement, a phenomenon that is consistent with the inherent drive for professionalism. It reflects the high autonomy motivation of the teachers in developing themselves or in complying with their job requirements (Fütterer et al., 2024; Karnadi & Istiyani, 2024).

The active engagement reflects teachers' commitment to participate regularly, even though the frequency of participation does not always directly correlate with the quality of deep reflection (Chen et al., 2023). However, there is a significant outlier, a respondent with a low engagement score, which highlights an extreme individual variance (Bergdahl, 2022). This low score could be interpreted as an indication of resistance towards the new format of learning, experience of digital fatigue, or having adaptation obstacles towards the cognitive or technical demand of the program (Bergdahl, 2022; Hernández-Barco et al., 2024). Therefore, the high average engagement highlights the program's overall effectiveness. The low engagement level underscores the need for personalized and adaptive program design, taking into account the different needs and challenges in various online professional learning contexts (Prestridge & Tondeur, 2015).

The cluster analysis result identifies three teachers profiles based on their engagement pattern. A high engagement cluster profile is interpreted as teachers who are commitment-driven, in which their intrinsic motivation is high. It is aligned with engagement or autonomy as suggested by Reeve & Tseng (2011) and Lee et.al (2001). Teachers in this cluster exhibit active participation along with high cognitive-emotional investment, reflecting their personal desire to improve the quality of their instructional practices through professional development. On the other hand, a low engagement cluster is likely to indicate compliance in the sense that their participation is more of a formality. Their low engagement shows that their participation might be driven by external demand or administration obligation, such as certification or work requirements. It is usually unaccompanied by personal acceptance or program internalization. Therefore, it results in superficial engagement (Diamond & Bulfin, 2025).

The other two extreme profiles represent the dichotomy of commitment and compliance. The moderate but passive cluster offers a unique spectrum of engagement. This cluster demonstrates moderate cognitive and emotional engagement; however, their agentic engagement score is relatively low. This could be interpreted as silent or passive engagement, in which teachers participate and process the material internally, but they do not demonstrate initiative, advocacy, or proactive actions to implement or adapt to the learning (Diamond & Bulfin, 2025). This profile highlights the challenge of transforming internal engagement into real action and emphasizes that motivation can be internalized at a certain level. Nevertheless, it remains hindered by contextual or structural factors that limit teacher agency. Therefore, this prevents the full shift from compliance to commitment (Reeve & Tseng, 2011).

The findings of this study provide a significant contribution to the engagement theory by applying and validating the multidimensional model; behaviour, emotional, cognitive, and agentic in the specific context of online teacher professional development. Especially, the differentiation found in cluster profiles widens the understanding of engagement dynamics in a professional learning environment, demonstrating that high behavioural engagement is not

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always supported by cognitive, emotional, or agentic investment (Reeve, 2012; Reeve & Tseng, 2011). This dynamic enriches the compliance vs commitment framework and emphasizes that engagement dominated by a behavioural dimension (formality compliance) indicates that teachers only focus on their performance because they want to comply with the external requirements nd not on the full and reflective adoption driven by personal commitment. Conversely, the cluster with a high score on all dimensions, including agentic, reflects the shift from true commitment and care of the profession, in which teachers act proactively to advance their teaching practices, surpassing the formal requirements (Diamond & Bulfin, 2025). By so doing, this study highlights the importance of a training program that explicitly targets and supports the agentic dimension to ensure the transformative commitment and not just transactional compliance.

Based on the various engagement profiles, there are practical implications of this study for the professional teacher education provider. Given the marked differences in agentic engagement across clusters, program providers can adopt concrete design principles; such as structured choice points, opportunities for learner-led task modification, and feedback mechanisms that allow participants to shape instructional pacing and resources. In addition, monitoring indicators like learner-initiated contributions, use of optional pathways, and patterns of self-directed task revision can help providers track changes in agentic engagement and adjust techno-pedagogical supports accordingly. In the future, a program should adopt a more targeted and adaptive approach, especially in designing specific interventions for teachers identified in low engagement and moderate but passive clusters. These interventions should focus on increasing minimal participation and strategically fostering teachers' agency, which refers to their ability to lead, take initiative, and adapt instruction based on their class context. This could be achieved through project-based activities, assignments requiring autonomous decision-making, or feedback mechanisms that nurture a sense of belonging. Additionally, the provider should implement a monitoring system for sustainable multidimensional engagement, not only attendance, to early detect teachers at risk of disengagement. This enables quick support adaptation to convert compliance-based engagement into transformative commitment.

Conclusion

In summary, this study makes a significant empirical contribution by identifying three engagement cluster profiles that differ among teachers in their online professional training. This finding confirms both the multidimensional nature of teachers' engagement and essential theoretical aspects by mapping the profiles onto a compliance and commitment spectrum. Specifically, the low engagement and moderate but passive cluster highlight that superficial active participation often conceals shallow cognitive-emotional engagement and low teacher agency. Therefore, the study's findings open up crucial opportunities for professional teacher education providers to shift from a one-size-fits-all approach to online training strategies that are more differentiated and targeted. This change also aims to ensure that future interventions meet administrative requirements and effectively foster deep commitment and teacher agency to improve the quality of sustainable teaching.

Recommendation

There are limitations to this study. First, the data were obtained from around 200 in-service informatics teachers; therefore, the findings on engagement profiles and their relationship with commitment or compliance might not be generalizable to other subjects or levels, such as primary teachers or social science teachers. Second, relying on self-report

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surveys introduces response bias, as respondents might tend to report based on social desirability instead of their true experiences. Third, the cross-sectional nature of this analysis only captures a snapshot of engagement at a specific point in time, which does not allow for a deep understanding of its dynamics and the longitudinal evolution of teachers' engagement profiles. As professional development programs progress, it is crucial to understand the long-term impacts of these interventions. Therefore, future studies should employ mixed-method and longitudinal designs to acquire a more comprehensive understanding. Upcoming research should focus on a robust and holistic approach to understanding the dynamics of teachers' engagement. To address self-report bias, future studies should combine self-report data with objective learning analytics to validate the findings. Additionally, it should test the generalizability of the results across larger populations, including teachers from various disciplines and countries, to enhance the external validity of the proposed engagement model. These approaches will enrich the theory and practice of professional teacher education in the digital era.

Beyond these limitations, the findings suggest several practical directions. For PPG policymakers, the varied engagement profiles highlight the importance of designing professional development policies that offer flexible learning paths, incorporate adaptive digital supports, and allocate resources for ongoing monitoring of teachers' agentic engagement over time. For in-service teachers, the results emphasise the value of developing reflective, self-directed learning habits, such as documenting instructional decisions, experimenting with learner-centred strategies, and using digital tools to monitor their own engagement patterns to enhance both commitment and instructional autonomy. Implementing these recommendations in future programme cycles will help align policy planning and classroom practice with the multidimensional nature of teacher engagement identified in this study.

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