

# Self-directed professional development: An algorithmic and activity-based model for teachers

Ainur Sagimbayeva<sup>1,\*</sup>, Darazha Issabayeva<sup>2</sup>, Shirinkyz Shekerbekova<sup>1</sup>, Nurzhamal Oshanova<sup>1</sup>,  
Laura Smagulova<sup>3</sup>, Botakoz Tulbassova<sup>1</sup>

<sup>1</sup> Department of Informatics and Informatization of Education, Abai Kazakh National Pedagogical University, Almaty 050010, Kazakhstan

<sup>2</sup> Department of artificial intelligence and Big Data, Al-farabi Kazakh National University, Almaty 050038, Kazakhstan

<sup>3</sup> Department of Information Technology and Artificial Intelligence, Zhetysu University named after I. Zhansugurov, Taldykorgan 040000, Kazakhstan

\* Corresponding author: Ainur Sagimbayeva, [a.sagimbaeva@abaiuniversity.edu.kz](mailto:a.sagimbaeva@abaiuniversity.edu.kz)

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**Abstract:** This study aims to examine the impact of an innovative self-directed professional development (SDPD) model on fostering teachers' professional development and improving their ability to manage this development independently. A quantitative research method was adopted, involving 60 participants from Almaty State Humanitarian and Pedagogical College No. 2, Almaty, Kazakhstan. Descriptive and inferential statistics were used to assess the SDPD model's effectiveness, specifically in promoting teacher engagement, adoption of new pedagogical techniques, and improvement in reflective practices. The study findings reveal that teachers, particularly in developing regions, often face challenges in accessing formal professional development programs. The implementation of the SDPD model addresses these barriers by providing teachers with the tools and strategies required for self-improvement, regardless of geographic or economic constraints. The study participants in the pilot phase showed increased engagement with new pedagogical methods, improved reflective practices, and greater adaptability to emerging educational technologies. The algorithmic aspect of the model streamlined the professional development process, while the activity-based approach ensured that learning remained practical and relevant to teachers' everyday needs. By offering a clear framework for continuous improvement, the model addresses the gaps in formal training access and cultivates a culture of lifelong learning. These findings suggest that the SDPD model can contribute to elevating teaching standards globally, particularly in regions with limited professional development resources.

**Keywords:** ability; innovative approach; professional development; professional growth; self-directed professional development model; teachers

## 1. Introduction

Professional development for teachers is an essential element in improving educational quality and effectiveness worldwide (Gore et al., 2017; Hennessy et al., 2022). However, many educators, particularly in developing regions, encounter important barriers, such as limited access to formal training programs, inadequate resources, and challenges in adapting to new technologies (Mercader, 2020; Okoye et al., 2023). These challenges highlight the need for innovative, adaptable models that enable teachers to manage and enhance their professional growth independently (Ghamrawi et al., 2024; Mhlongo et al., 2023).

The field of education is experiencing important transformation due to rapid technological advancements, evolving pedagogical practices, and an increasing focus

on personalized learning (Grassini, 2023; Karakose et al., 2023). Professional development has traditionally been a formal, institution-driven process, typically delivered through workshops, seminars, and training sessions (Perry and Booth, 2024; Popova et al., 2022). However, recent global trends have emphasized a shift toward self-directed learning, where educators actively manage their own professional growth (Taylor, 2023).

In the broader field of professional development (PD), one sub-area that has gained increasing attention is self-directed professional development (SDPD), particularly for teachers (Golightly, 2022). SDPD allows educators to take ownership of their learning by setting personalized goals, selecting relevant learning resources, and reflecting on their progress (Simmie et al., 2024). This approach contrasts with the traditional, top-down PD model, which is often rigid and less responsive to the diverse needs of individual teachers (Diamond and Bulfin, 2023).

Studies show that self-directed learning fosters greater autonomy and intrinsic motivation, both critical for long-term professional growth (Morris, 2019; Power and Goodnough, 2019). Teachers engaged in SDPD tend to develop more relevant skills, demonstrate higher adaptability to new educational technologies, and improve classroom practices (Liu et al., 2020). However, the successful implementation of SDPD models requires structured frameworks that balance flexibility with clear guidance, ensuring that teachers can effectively navigate their development paths (Koay, 2023).

Empirical studies (Celeste and Osias, 2024; Wagner et al., 2024) conducted in various international contexts highlight common issues faced by teachers, including limited access to continuous learning opportunities and difficulties in integrating technology into their teaching practices. These studies (Wang and Wang, 2023) provide the foundation for understanding the authors' perspective that a self-directed, algorithmic approach can offer a practical and effective solution. By grounding the SDPD model in these empirical findings, this study positions itself within the broader discourse on educational innovation and teacher empowerment.

The problem at the heart of this study is the widespread lack of adequate professional development opportunities for teachers, which poses an important barrier to educational progress worldwide (Karakose et al., 2022; Papadakis and Kalogiannakis, 2020). Several educators, especially in resource-constrained regions, do not receive the support and training necessary to keep up with evolving educational technologies and methodologies. Traditional professional development programs are often inaccessible, inflexible, or insufficient to meet these needs.

In Kazakhstan, professional development for teachers has historically been shaped by government-led initiatives (Nurgaliyeva et al., 2023). While these initiatives provide a foundational framework for teacher training, there is a growing demand for more flexible and individualized approaches (Nagima et al., 2022).

Thus, in Kazakhstan, the formal professional development system continues to rely heavily on centralized, standardized programs that often fail to address the unique needs of teachers, especially those in rural or underserved regions (Abildina et al., 2024). These programs often focus on general pedagogical theory rather than practical, context-specific strategies. Furthermore, limited access to quality resources and ongoing mentorship exacerbates the gap between the growing demand for

continuous learning and the availability of effective PD opportunities. Teachers, especially those in remote or underserved areas, often encounter obstacles such as limited access to formal training, inadequate resources, and a lack of ongoing support. This study addresses these challenges by proposing a self-directed, algorithmic, and activity-based model tailored to the needs of teachers in Kazakhstan (Zhumash et al., 2021).

This study specifically addresses the need for a structured yet self-directed approach to teacher development in Kazakhstan. The proposed algorithmic and activity-based model provides a framework for teachers to independently assess their developmental needs, set goals, and engage in relevant activities that promote skill enhancement. While the idea of SDPD is not new, its integration with an algorithmic approach that offers step-by-step guidance and practical activities tailored to the Kazakhstani education system remains relatively unexplored. Current research suggests that although self-directed learning shows great potential, there is a need for models that provide structure without compromising teachers' autonomy. The degree to which this approach can be tailored to the specific cultural and educational context of Kazakhstan has not been fully examined, making this study both timely and important.

While SDPD has proven effective in fostering autonomy and sustained growth among teachers, a significant gap remains in our understanding of how to implement structured models tailored to specific educational contexts, such as Kazakhstan. Research has proven the benefits of SDPD, particularly in environments where formal professional development programs are either inaccessible or inadequate. However, the question of designing a model that combines self-directed learning with algorithmic guidance—particularly one that addresses the unique needs and challenges faced by Kazakhstani teachers—remains unanswered (Tajibayeva et al., 2023).

Despite the growing recognition of SDPD's value in the world, few studies have examined its application in Kazakhstan, where centralized and standardized professional development programs dominate (Ospankulov et al., 2023). Furthermore, there is limited understanding of how algorithmic and activity-based models can offer both flexibility and structure to teachers in their development. The extent to which an algorithmic framework can support self-assessment, goal setting, and the practical application of new skills within the constraints of the Kazakhstani education system remains largely unexplored.

The question that motivates this study is: How can a SDPD model grounded in algorithmic processes and activity-based learning, be effectively implemented for teachers in Kazakhstan to improve their professional growth and address the limitations of current centralized systems? Investigating this question is the logical next step given the current understanding of SDPD and the pressing need for more personalized, flexible, and context-specific approaches to teacher development in Kazakhstan. Addressing this gap will provide crucial insights into how educators in the region can take ownership of their learning while navigating the constraints of their professional environment.

## **1.1. Significance of study**

This study is important because it addresses the pressing issue of fostering teachers' PD and empowering them to manage their professional growth independently (Tay et al., 2021). Resolving the research problem will generate several key benefits. First, it will provide teachers with a more effective and personalized pathway for continuous professional development, leading to a better understanding and application of modern teaching methods (Sims and Fletcher-Wood, 2021). Second, it will provide a solution to the accessibility issues that limit teachers' participation in traditional development programs (Guilbaud et al., 2021). This research demonstrates the practical utility of the SDPD model in Kazakhstan, presenting a scalable solution for teacher PD. The model's flexibility makes it particularly valuable in rural or resource-limited settings, where access to conventional PD programs is often constrained. Moreover, the model's success in fostering continuous learning suggests that it could be integrated into national education policies to enhance teacher development across the country. Finally, the findings will serve as a valuable resource for educational policymakers in Kazakhstan, offering insights into how self-directed development models can enhance overall teaching quality and, ultimately, enhance student outcomes nationwide.

## **2. Method**

### **2.1. Research design**

This study employed a quantitative data collection technique, selected to measure specific outcomes, such as teachers' engagement with the model, their progress in meeting self-set goals, and the model's impact on their professional development. The use of a quantitative approach was driven by the need for scalable and replicable results, providing a solid foundation for further research (Pratt et al., 2020) and supporting the potential for broader implementation of the model within the Kazakhstani education system.

### **2.2. Research questions**

Q1: How effective is the SDPD model in enhancing teachers' engagement with innovative teaching practices?

Q2: To what extent does the SDPD enhance teachers' reflective abilities and adaptability to new educational technologies?

Q3: Can the SDPD model provide a viable and scalable solution for professional development in resource-limited regions?

### **2.3. Objectives**

This study aimed to examine the impact of the SDPD model on fostering teachers' professional development and improving their ability to manage their professional growth independently.

## 2.4. Research sample formation

The study sample consists of 60 teachers from Almaty State Humanitarian and Pedagogical College No. 2, Almaty City, Kazakhstan. The study participants were divided into an experimental group (EG) ( $n = 30$ ) and a control group (CG) ( $n = 30$ ), with ages ranging from 32 to 57. The mean age was  $43.66 \pm 1.1$  years (SD 6.4). Of the participants, eight were male and 52 were female, representing various age ranges (Table 1).

**Table 1.** Descriptive information provided by respondents.

Gender	<i>N</i>	%
Experimental group (EG)		
Male	5	19.7
Female	25	80.3
Total	30	100
Age		
32–37	5.5	18.2
38–43	10.1	31.7
44–49	11	32.7
50–56	2.4	11.4
57+	1	6
Control group (CG)		
Male	3	18.6
Female	27	81.4
Total	30	100
Age		
32–37	5.5	18.2
38–43	9.3	30.7
44–49	11	32.7
50–56	2.2	11.4
57+	2	7

## 2.5. Experimental manipulation and research procedures

The study comprised several consecutive stages:

Stage 1: Participant Selection

Two groups of teachers were selected for the study:

(1) Experimental group: This group followed the SDPD model.

(2) Control group: This group continued with the college's standard professional development programs.

Participants were matched based on gender, age, course of study, and level of preparation to ensure comparability between the groups.

Stage 2: Pre-Test Assessment

Before the intervention, both groups took a pre-test to assess their initial professional competencies. The pre-test included quantitative questions to evaluate pedagogical knowledge, teaching strategies, and technological proficiency.

### Stage 3: Implementation of the SDPD Model

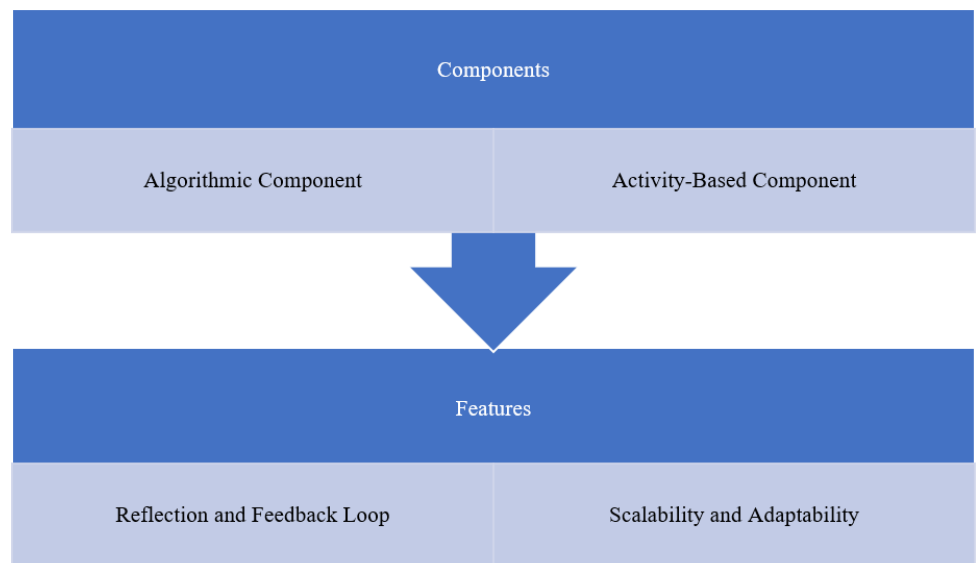
The SDPD model was implemented for the development of professional competencies based on the experimental sample of respondents.

### Stage 4: Post-Test Assessment

After six months of the intervention, both groups completed a post-test similar to the pre-test. The post-test was used to measure and analyze changes in pedagogical competencies, teaching practices, and technological integration.

## 2.6. Description of the self-directed professional development (SDPD) model

This model aims to provide educators with practical tools and strategies to enhance their professional growth independently, addressing global challenges related to limited access to formal training programs. By empowering teachers to take control of their own learning and development, the model seeks to improve their engagement with new pedagogical techniques, adaptability to emerging technologies, and overall teaching effectiveness. According to the established provisions, the model for fostering teachers' professional development and improving their ability to manage professional growth independently consists of the following structure (Figure 1).



**Figure 1.** SDPD model fostering professional development of teachers.

It integrates two key components: algorithmic processes and activity-based learning, offering a structured yet flexible framework that accommodates the diverse needs of educators.

1) **Algorithmic Component:** The algorithmic aspect of the model provides a systematic pathway for teachers to identify their developmental needs, set goals, and track their progress. It utilizes a digital platform where teachers complete a self-assessment survey to evaluate their current skill levels and areas for improvement. Based on their responses, the algorithm generates a personalized development plan, including a series of recommended activities, resources, and milestones. This

component is designed to guide teachers through a step-by-step process, helping them stay on track while adapting the plan to their individual contexts.

2) **Activity-Based Component:** The activity-based component focuses on hands-on, practical learning experiences directly related to teachers' daily classroom practices. These include interactive workshops, peer collaboration sessions, micro-teaching exercises, and technology integration tasks. The activities are designed to be self-paced, allowing teachers to engage with the content at their convenience while ensuring they can immediately apply what they learn in their own teaching environments. By focusing on practical, real-world applications, this component ensures that professional development remains relevant and meaningful.

3) **Reflection and Feedback Loop:** A core feature of the SDPD model is the integration of reflective practices and continuous feedback. Teachers are encouraged to maintain a reflective journal where they document their learning experiences, challenges, and achievements. Additionally, they can access a feedback loop through peer networks or mentor support within the platform, fostering collaborative learning and the exchange of best practices. This reflective component is essential for helping teachers internalize new skills and adapt them to their specific educational contexts, further improving the model's overall effectiveness.

4) **Scalability and Adaptability:** The SDPD model is designed for scalability, making it suitable for implementation in both well-resourced and resource-limited regions. The digital nature of the algorithmic component allows for widespread access, even in remote or underserved areas where traditional professional development opportunities are limited. The activity-based learning component is flexible, enabling customization to fit different educational contexts and teaching levels, ensuring the model remains relevant and practical across diverse settings.

By integrating these components, the SDPD model provides a comprehensive, self-directed approach that supports teachers in their professional development journey. It empowers educators to take control of their own growth, addressing gaps where traditional programs fall short, and promoting a culture of lifelong learning and adaptability in teaching practices.

## **2.7. Data collection tools**

### **1) Pre-Test and Post-Test Surveys**

The primary data collection tools were pre-test and post-test surveys administered to both groups, designed to measure the following:

(1) **Pedagogical Knowledge:** The teachers' understanding of teaching methodologies, classroom management, and assessment strategies.

(2) **Technological Proficiency:** The ability to integrate technology into teaching, with a focus on utilizing digital tools for classroom instruction.

(3) **Professional Competence:** Self-reported confidence in various professional skills, including communication, student engagement, and collaboration with peers.

### **2) Self-Assessment Tools**

The self-assessment focused on:

(1) **Teaching Methodology Mastery:** The teachers rated their abilities in employing diverse teaching strategies.

(2) Goal Achievement: Teachers regularly assessed their progress in relation to the goals they had set at the beginning of the program.

3) Algorithmic Framework Engagement Metrics

A custom-built algorithmic framework guided the experimental group through their self-directed professional development journey, while also collecting engagement data, including:

(1) Completion Rates: The percentage of participants who completed each stage of the development process.

(2) Time Spent: The amount of time teachers dedicated to engaging with each component of the framework.

(3) Activity Participation: Participation in workshops, peer collaboration activities, and reflection exercises.

**2.8. Data analysis**

The data analysis for this study employed a combination of descriptive and inferential statistics to evaluate the effectiveness of the self-directed professional development (SDPD) model.

**3. Results**

The experimental group achieved better results compared to the control group, as shown by the descriptive statistics in **Table 2**.

**Table 2.** Descriptive statistics table for Pre-Test and Post-Test results.

Group	Test	Mean	Standard deviation (SD)	Minimum	Maximum
EG	Pre-Test	60.8	4.5	55	66
	Post-Test	85.4	5.2	78	92
CG	Pre-Test	59.3	4.8	52	65
	Post-Test	70.3	6.1	60	82

The data show that the experimental group (EG), which followed the SDPD model, showed a substantial improvement from pre-test to post-test, with an average score increase of 24.6 points. In contrast, the control group (CG) experienced a modest increase of only 11 points (**Table 3**). The lower standard deviation in the experimental group’s pre-test and post-test scores suggests more consistent gains in knowledge and skills, while the CG showed wider variation. These results imply that the SDPD model is more effective in enhancing teachers’ pedagogical knowledge, technological proficiency, and professional competence compared to the traditional methods used in the control group.

The paired sample *t*-test results show that the SDPD model was significantly more effective in improving teachers’ professional competencies compared to traditional methods. The EG showed a much larger mean difference and a higher *t*-value, with a *p*-value indicating very strong statistical significance. Conversely, while the CG also showed significant improvement, the effect size was smaller.



**Table 3.** Results of paired sample *t*-Test for experimental and control groups.

Group	Test	Mean difference	<i>t</i> -value	<i>p</i> -value
EG	Pre-Test vs. Post-Test	24.6	9.24	< 0.001
CG	Pre-Test vs. Post-Test	11.0	3.12	0.003

The independent sample *t*-test results show that the EG, which participated in the SDPD model, achieved significantly higher post-test scores than the control group, which followed traditional professional development methods. This indicates that the SDPD model was more effective in improving teachers’ professional competencies, technological proficiency, and pedagogical skills. The very low *p*-value (< 0.001) suggests a strong level of confidence in these results, confirming that the observed differences between the groups are not due to chance.

**Table 4** shows the independent sample *t*-test results for post-test scores.

**Table 4.** Results of independent sample *t*-Test for Post-Test scores.

Group	Mean (Post-Test)	Standard deviation (SD)	<i>t</i> -value	<i>p</i> -value
EG	85.4	5.2	9.15	< 0.001
CG	70.3	6.1		

The large effect size of Cohen’s *d* = 2.74 demonstrates that the SDPD model had a practically significant effect on the professional competencies of the teachers in EG. This indicates that the SDPD model was not only statistically effective but also highly meaningful in terms of real-world improvements in teacher skills and knowledge, greatly surpassing the gains observed in the CG using traditional methods.

**Table 5** presents the results of the effect size (Cohen’s *d*) for the SDPD model.

**Table 5.** Effect size (Cohen’s *d*) for the Self-Directed professional development model.

Group	Mean (Post-Test)	Standard deviation (SD)	Effect size (Cohen’s <i>d</i> )
EG	85.4	5.2	2.74
CG	70.3	6.1	

The analysis of engagement metrics shows that high levels of engagement with the SDPD model were strongly correlated with greater improvements in professional competencies. Completion rates and time spent on activities showed a particularly strong correlation with post-test scores, indicating that the more actively teachers participated in the SDPD framework, the more significant their skill development. Peer collaboration and reflection sessions also contributed to professional growth, albeit with a slightly lower correlation, suggesting that these components of the SDPD model further supported teachers’ overall development.

**Table 6** presents the results of engagement metrics for EG.

**Table 6.** Engagement metrics for EG.

Metric	Mean	Standard deviation (SD)	Correlation with post-test scores ( <i>r</i> -value)
Completion rate (%)	92%	5.1	0.82
Time Spent on activities (hours)	15.6	2.4	0.76
Participation in peer collaboration and reflection (sessions)	8.7	1.3	0.68

#### 4. Discussion

This study aims to examine the effect of the innovative SDPD model on fostering professional development for teachers and improving their ability to manage professional growth independently. The analysis revealed that teachers in the EG, who engaged with the SDPD model, showed significant improvements in their post-test scores compared to the CG, which followed traditional professional development methods. This suggests that the SDPD model can serve as an effective alternative for professional growth, particularly in contexts where access to formal professional development programs is limited. The SDPD model empowered teachers by providing them the flexibility to manage their learning pathways and adapt activities to their specific needs (Bhatt, 2021). The high completion rate (92%), strong time engagement (15.6 h), and substantial participation in peer collaboration (8.7 sessions) show that teachers are willing to take charge of their development when given autonomy. Furthermore, the strong positive correlations between these metrics and post-test scores highlight the importance of active engagement in the learning process. The model's algorithmic structure, which personalizes content based on individual progress, creates a tailored learning experience. This is particularly relevant in Kazakhstan, where teachers may have varying levels of expertise in pedagogical knowledge, technological proficiency, and professional competence (Kapasheva et al., 2024). Teachers often face challenges such as limited access to high-quality professional development programs, and a lack of time due to heavy workloads (Ventista and Brown, 2023). Traditional professional development models often require physical attendance at workshops or conferences, which can be impractical for many teachers (Carpenter, 2016). In contrast, the SDPD model was designed to be flexible, self-paced, and accessible online. This approach addressed the issue of access by providing teachers with a virtual platform for continuous learning, allowing them to engage at their convenience. The results demonstrated that the SDPD model is effective in promoting continuous learning and adaptation in teaching practices (Ambreen and Arif, 2022). The significant increase in post-test scores in the experimental group suggests that teachers are not only acquiring new knowledge but are also successfully integrating these skills into their professional practices.

The large effect size (Cohen's  $d = 2.74$ ) further supports the practical impact of the SDPD model on teaching outcomes. The model's algorithmic nature encourages ongoing engagement by continuously adapting activities to align with teachers' progress, making it more likely for them to sustain their professional development over time. This is particularly important in a rapidly changing educational landscape, where new technologies and pedagogical strategies are constantly emerging. The study findings align with previous research on the benefits of self-directed learning

and personalized professional development. For instance, Lee et al. (2020) reported that teachers who engaged in self-directed learning reported greater satisfaction with their professional development experiences and showed improved classroom performance. Similarly, Blumberg et al. (2024) emphasized the importance of autonomy in professional growth, noting that teachers who are given control over their learning paths are more likely to engage deeply with the material.

In terms of flexibility, Yan et al. (2021) emphasized that online, self-paced models for professional development can reduce barriers related to time and location, aligning with the study results. The effectiveness of algorithmic frameworks was also noted by Zhang et al. (2020), who reported that, personalized learning models led to higher completion rates and better outcomes than traditional one-size-fits-all approaches. Moreover, Sancar et al. (2021) found that collaboration within professional development programs significantly enhanced teachers' ability to implement new strategies in the classroom, a finding echoed in this study's results.

However, some challenges remain. Sosibo (2019) noted that without proper guidance, self-directed models can sometimes result in uneven engagement, with some participants excelling while others struggle to keep pace. This study mitigated such risks by incorporating structured activities and regular reflection sessions, which helped maintain consistent engagement across participants. Thus, the SDPD model shows great potential as a tool for improving teacher competencies in Kazakhstan. Its algorithmic, activity-based design offers a flexible, personalized approach that effectively addresses many of the challenges Kazakhstani teachers face in accessing formal professional development programs.

## **5. Conclusions**

This study explored the effectiveness of the SDPD model in enhancing teachers' professional growth, with a focus on its impact on their engagement with new teaching practices, reflective abilities, and adaptability to emerging educational technologies.

The findings reveal that the SDPD model is effective in increasing teachers' engagement with innovative teaching practices. Teachers who participated in the model showed greater enthusiasm and active involvement in adopting new methodologies, suggesting that the model successfully promotes professional engagement.

The study confirms that the SDPD model significantly enhances teachers' reflective abilities and adaptability to new educational technologies. Participants reported improved self-assessment skills and a greater willingness to integrate technology into their teaching, showing the model's effectiveness in fostering adaptability and reflective practices.

The results support the conclusion that the SDPD model can serve as a viable and scalable solution for improving professional development, particularly in resource-limited regions. Its flexible, self-directed approach enables teachers to overcome barriers related to limited access to formal training programs, making it both applicable and impactful across diverse educational contexts.

Overall, the SDPD model presents a promising framework for transforming teacher professional development globally, addressing gaps in traditional programs, and promoting a culture of continuous learning and improvement. Future research could explore the broader application of this model to further validate its scalability and effectiveness across various educational systems and regions.

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