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## Longitudinal study of meta-learning: Advancing pre-service teachers' professional growth

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### Abstract

The relevance of the research is determined by the need to prepare pre-service teachers for continuous professional development in a rapidly changing educational landscape. This article examines the implementation of meta-learning as a tool that contributes to the formation of necessary competencies. To achieve this goal, a longitudinal study was chosen, during which 387 students from Kazakhstani universities were involved in meta-learning for a two-semester academic year. The research methods included qualitative surveys and in-depth interviews before and after the implementation of meta-learning, which allowed for the evaluation of changes in their competencies. The results showed significant growth in competencies related to continuous professional development, indicating the positive impact of meta-learning on the preparation of pre-service teachers. The conclusions emphasize the importance of integrating meta-learning into educational programs to enhance students' professional readiness. The prospects for further research involve a deeper analysis of various methods of meta-learning and their impact on other aspects of pedagogical training, as well as the study of long-term effects on the career development of the graduates.

**Keywords:** Continuous professional development, longitudinal study, meta-learning, pre-service teachers, professional development competencies.

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**Transparency:** The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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## **1. Introduction**

A complex society with its growing global problems is not satisfied with teachers' subject knowledge and pedagogical skills, but who are not capable of continuous development based on "action competence" [1]. Modern education requires pre-service teachers not only to have extensive knowledge of the subject but also the ability for continuous professional development (CPD). In a rapidly changing world, where educational standards and qualification requirements for specialists are constantly updated, it becomes crucial to form meta-knowledge and the mastery of metacognitive strategies among students [2-5].

This creates a need to introduce approaches into the educational process that promote the development of self-organization, self-direction, and self-regulation skills in learning [6-10]. As well as self-regulated behavior in learning [11]. One such approach is meta-learning, aimed at the development of metacognition and CPD competencies, making it a relevant tool in pedagogical education.

Along with the increasing complexity of pedagogical activities in Kazakhstani universities, several problems can be observed: a disciplinary approach in the organization of the educational process, the prioritization of subject-pedagogical competencies over metacompetencies, a lack of integration of meta-learning with traditional subject disciplines, and the postponement of learning for self-development. In this context, "acquired knowledge is evaluated rather than skills (cognitive, general, and Sagintaeva [12]). All of this complicates the process of preparing pre-service teachers for the real and forthcoming conditions of professional activity in a complex society.

Thus, there is insufficient preparation of future educators for CPD, which is related to the predominance of the traditional subject-oriented approach in educational institutions and the lack of proper integration of meta-learning. This leads to a shortage of practical skills and an insufficient understanding of the importance of constant self-development in the ever-changing educational environment.

This study aims to address the problem of inadequate preparation of pre-service teachers for continuous professional development through the implementation of meta-learning.

## **2. Literature Review**

CPD of pre-service teachers refers to activities that go beyond traditional academic work and are implemented based on resources from formal, non-formal, and informal education, which students organize and perform to deepen their knowledge, expand skills and competencies, and develop self-development experience. Our definition reflects the position of Abakah [13]: "CPD of university students is a specific activity based on the educational program and academic events aimed at changing and increasing professional knowledge, understanding the importance of development, skills, and relationships".

In existing research on the theory and practice of CPD, the goal is to improve students' academic and other achievements through modeling the pedagogical process, applying modern teaching methods and forms, monitoring achievements, and providing feedback [14, 15]. CPD leads to changes in educators based on cognitive dissonance in their thinking (Kizilbash [16] as well as the transformation of educators through peer learning Van der Merwe-Muller and Dasoo [17] and collaborative workplace design [18].

Research on the change in views of pre-service teachers and in-service teachers under the influence of CPD is also of interest, as well as students mastering scientific process skills within the context of CPD Molefe and Aubin [19] and the implementation of pedagogical practice and CPD tasks through reflective discourse among stakeholders [20]. Most studies focus on the target category of practitioner educators. Thus, the organization of learning aimed at forming CPD competencies has not yet received proper scientific justification.

To a greater extent, researchers talk about the CPD of teachers-practitioners: studies on changing attitudes under the influence of CPD and the teacher himself based on dissonance in thinking Kizilbash [16] about teachers' new views on natural science education, when students can conduct research based on their questions, Kurtén and Henriksson [21] on the transformation of teachers through learning from colleagues, Van der Merwe-Muller and Dasoo [17] collaborative workplace design [18]. In the context of the CPD of teaching students, its impact on improving academic and other achievements of students is substantiated through modeling the pedagogical process, applying modern methods and forms of teaching, monitoring achievements, and feedback [14, 15]. Mastering the skills of the scientific process, Molefe and Aubin [19] implemented the tasks of pedagogical practice through the reflexive discourse of stakeholders, Soh [20], mastering the strategy of Eyes High [22].

Thus, we associate the research gaps with the lack of elaboration of the principles of identifying CPD as a separate field of study, and the need to clarify the content and methods of CPD in the context of the educational activities of future teachers. The formation of CPD competencies is considered an indicator of targeted CPD training.

Among CPD competencies, we highlight cognitive, acmeological, socio-behavioral, and digital skills, which are transformed into the abilities and qualities of pre-service teachers' personalities based on the selection and implementation of "learn to learn" (self-development) strategies. In global practice, these competencies are viewed as transversal Cepic et al. [23] and universal [24]. CPD competencies, while aiding in course mastery, allow learners to move beyond subject boundaries into the broad field of metacognition. These competencies confirm that "learning is student-centered and supports the principles of the Bologna process by promoting... lifelong learning" [25].

The concept of forming CPD competencies in pre-service teachers is detailed in the works of Mukanova [26] and Murzalinova et al. [27]. The purposeful formation of CPD competencies is supported by meta-learning, which implements CPD through its integration with subject-pedagogical content. Skills in meta-learning and metacognition, aimed at engaging students in "learning to learn," are of "vital importance for students in secondary and post-secondary education" Chacón-

Díaz [3] from "changing students' routines" as learning procedures Valenta and Enge [5] to supporting "the relevance of educators in the digital age" [2].

The development of relevant skills is proposed through "lesson planning" based on the "integration of pedagogy and technology" in the logic of "learning to teach" Børte and Lillejord [28] conceptualizing "learning at the meta-level" Nachlieli and Elbaum-Cohen [29] and metacognitive strategies for students, which include "goal setting and planning, as well as monitoring, evaluating, and adjusting their behavior in learning" [30]. A special course called "Learning to Learn" is designed to "teach college students the science of how learning works, how to take responsibility for their own learning, and how to effectively apply learning strategies to achieve their academic goals using a structure of cognitive apprenticeship" [31].

Meta-learning, with the potential of CPD, can be viewed as working with the "missing links" of pedagogical education and included in teacher training programs as an element of pro-social education, Mgaia and Milanga [32] as "proactive" differentiated education to meet the diverse expectations and needs of students, Kahmann et al. [33] as the foundation for developing the pre-service teachers' potential readiness for lifelong education [34]. It is worth noting that meta-learning requires a shift from "transmissive, linear, fragmented, one-dimensional" teaching models to a metamodel that supports the development of leadership skills and the training of novice teachers [35].

Kazakhstani authors consider teaching to be the "cornerstone for the other three elements – curriculum, teaching, and assessment". The goal of education, whether it is "mastering content, creating new knowledge, employment, or contributing to regional development," "puts students at the center of the academic process" [12]. Students can influence the quality of the academic process as they "precisely describe their learning," and their "voice" is important for teaching [36]. Thus, meta-learning is seen as a foundation for advancing students in a multi-level hierarchy of educational goals. Researchers thus justify the significance of the meta-approach in "students creating learning materials from the perspective of learning through learning" Ribosa and Duran [37] and more broadly – in the development of critical thinking Wason [38] and "self-regulated learning in STEM education" based on "metacognition, strategic adaptation, and learner motivation" [39]. Overall, meta-learning is being studied as an approach for continuous pedagogical education.

By offering meta-learning as a CPD tool at an early stage of continuing teacher education, we clarify the limitations of the above studies on meta-learning as a methodology and approach to updating teacher education. The concept of the formation of CPD competencies among future teachers is presented in detail in the work [27].

In our study, meta-learning is a self-organized activity in the educational environment, involving learners in coordinating self-education, self-development, and self-improvement through strategies from formal, non-formal, and informal learning to expand knowledge, skills, competence, and professional-oriented experience. Meta-learning organizes teaching and learning in the modalities of lifewide and lifedep learning. Thus, meta-learning supports continuous learning within its competence framework: "1) Information literacy, 2) Self-regulation and self-direction, 3) Autonomous motivation, 4) Beliefs and learning strategies, 5) Initiative and persistence, and 6) Adaptability and resilience" [40]. These competencies ensure lifelong prospects for professional and personal development.

Thus, there is a lack of empirical research on the integration of meta-learning into pedagogical programs and its impact on the formation of CPD competencies in pre-service teachers. This article will fill this gap in the research by providing data and analysis specific to the local context. The goal of the article is to determine the impact of meta-learning on the formation of CPD competencies in student-teachers and clarify the prospects for further research in this area.

### *2.1. Research Questions*

RQ1. Based on the analysis of data collected before and after meta-learning (Quantitative analysis), what is the dynamics of change in CPD competencies among pre-service teachers as a result of meta-learning?

RQ2. Based on the analysis of in-depth interview data (qualitative analysis), how do future and novice educators describe what they learned through meta-learning, and how did they apply the knowledge gained in their professional development?

## **3. Methodology**

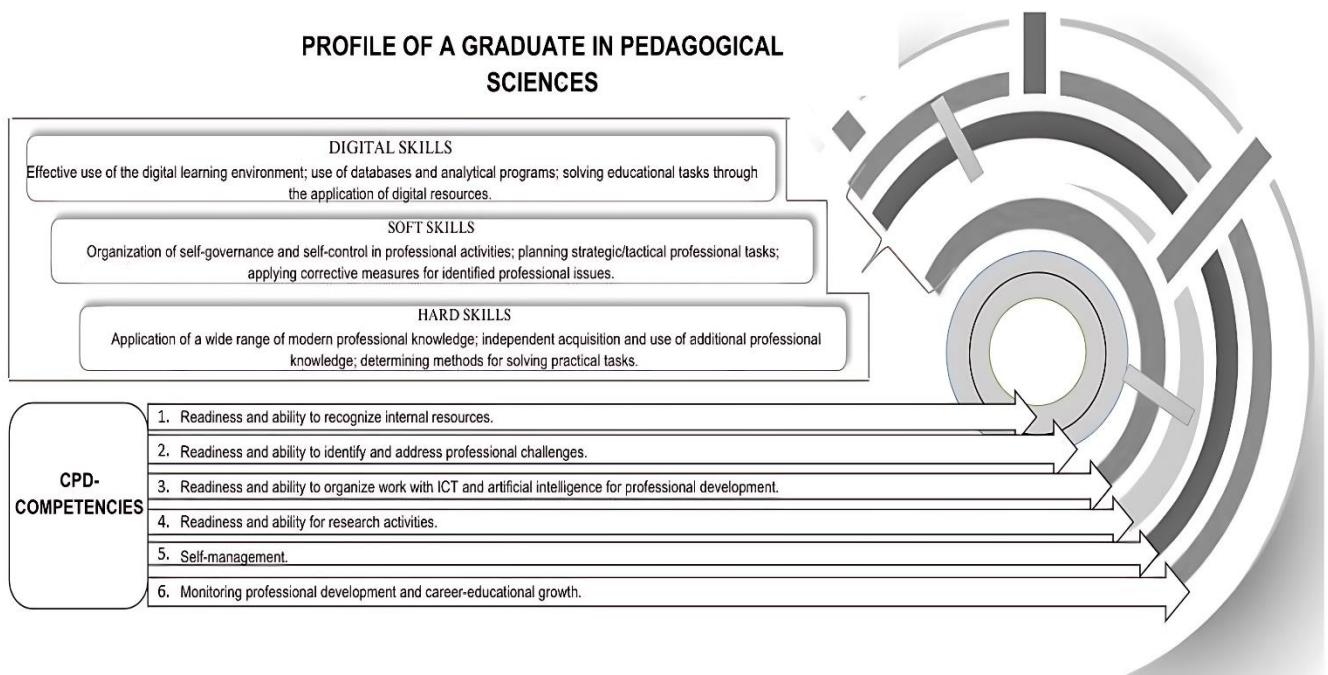
To achieve the research goals and answer the research questions, a longitudinal study with an educational intervention was conducted from September 2023 to October 2024, which allowed for the assessment of the impact of meta-learning on CPD competencies among student-educators. The study was conducted in several stages. Initially, students were informed about the resources available for CPD to optimize their activities. A survey was then conducted to assess their existing (by the 3rd-4th year) level of professional development. Following this, meta-learning was introduced for students over two semesters. After completing the meta-learning process, surveys and in-depth interviews were conducted with students who had advanced to their 4th year, as well as with graduates. During the interviews, participants created a "tree of meanings" representing their CPD activities.

The study was carried out at the pedagogical faculties of Kozybayev University (Petropavlovsk city) and Buketov University (Karaganda city). The targeted sample consisted of students enrolled in the following educational programs: "Pedagogy and Psychology," "Preschool Education and Training," "Pedagogy and Methods of Primary Education," "Special Education," and "Pedagogy and Psychology." A total of 387 students participated, including 330 undergraduate students and 57 graduate students. Among them, 211 were in their penultimate (3rd) year and 176 were in their final (4th) year. Participants were selected based on voluntary participation, sufficient diversity in the student body, the intensity of the phenomenon under study, and the ability to provide insights into the problem.

### 3.1. Research Materials

The study materials included the "Profile of a Graduate" (Figure 1), principles for updating educational programs to integrate subject-specific, pedagogical, and CPD competencies (Figure 2), and the content of the meta-learning program. The figures were supplemented by the concept of CPD, as presented in the works of Mukanova [26] and Murzalinova et al. [41]. The organization of meta-learning was implemented through an action research method, also referred to as the "learning-by-practice process" [42]. The implementation included.

- Improving teaching practices - enhancing teaching, learning, and assessment by progressively expanding CPD processes and activities based on the integration of subject-pedagogical competencies with CPD competencies (September 2023 - June 2024).
- Direct, open, experimental observation of CPD processes integrated into the educational process, with the goal of analyzing the impact of CPD competencies on the formation of professional-pedagogical competence among pre-service teachers.
- Interpretation of data through the methodology of extreme meanings (October 2024), with clarification of new research questions[12].
- Meta-learning was accompanied by continuous reflection from the research group members. Students involved in action research participated in reflective sessions. Let's consider the features of meta-learning for the development of competencies in CPD.
- The meta-learning process aimed at forming CPD competencies involved regular integration into teaching across all types of classes (lectures, practical sessions, independent work under the guidance of the instructor), as well as preparation and defense of graduation theses. Unlike traditional teaching, meta-learning emphasizes strategies such as scaffolding, coaching, and training. The instructor's role is that of a content designer, "mentor, guide, assistant, standing behind, instructor, coach" [6].



**Figure 1.**  
Profile of a Graduate.

The student-centered nature of meta-learning aims to form students' own learning systems, leading to an individualized teaching style, sustained motivation, independence, responsibility, and the personalization and personification of teaching. Meta-learning focuses on fostering a growth mindset. Students view difficulties in learning activities as motivators for CPD, aimed at overcoming challenges through various self-development strategies. In a growth mindset and CPD activities, students expand the boundaries of their personal potential. The overall goal of development and the subject position of the learner ensure synergy between these two types of activities.

The reflective component of meta-learning involves guiding students in reflecting on their own growth mindset and points of growth, as well as sharing proven metacognitive practices. CPD competencies require feedback and purposeful reflection, where the instructor, in the position of "from the depth of the classroom," shares their own experiences of meta-learning and metacognition. Students reflect on the personal significance of the CPD strategy applied in their independent work. During the reflection process, students explain the self-development strategies they have "adopted" in practice, demonstrating maximum adaptability to their established learning style and integrating them into their learning experience. This creates the foundation for managing one's own CPD, aligning with the concept of reflection recognized as a "predictor of professional development" [43].

The translation of understanding into action occurs through integrative assignments, where students learn how the learning process works and establish for themselves the connection "between metacognitive awareness and personal competence in learning" [44]. Learning how to learn becomes a central goal of the CPD educational system, where the process of self-organizing effective learning is just as important as the outcome. For the formation of CPD competencies, the methodological significance of research activity in the context of an educational landscape of innovations, initiatives, and reforms is critical. Therefore, final-year students complete qualification projects, including on CPD topics. The methods and forms of research activities in such projects serve as key tools for CPD and confirm students' readiness and ability to address project tasks.

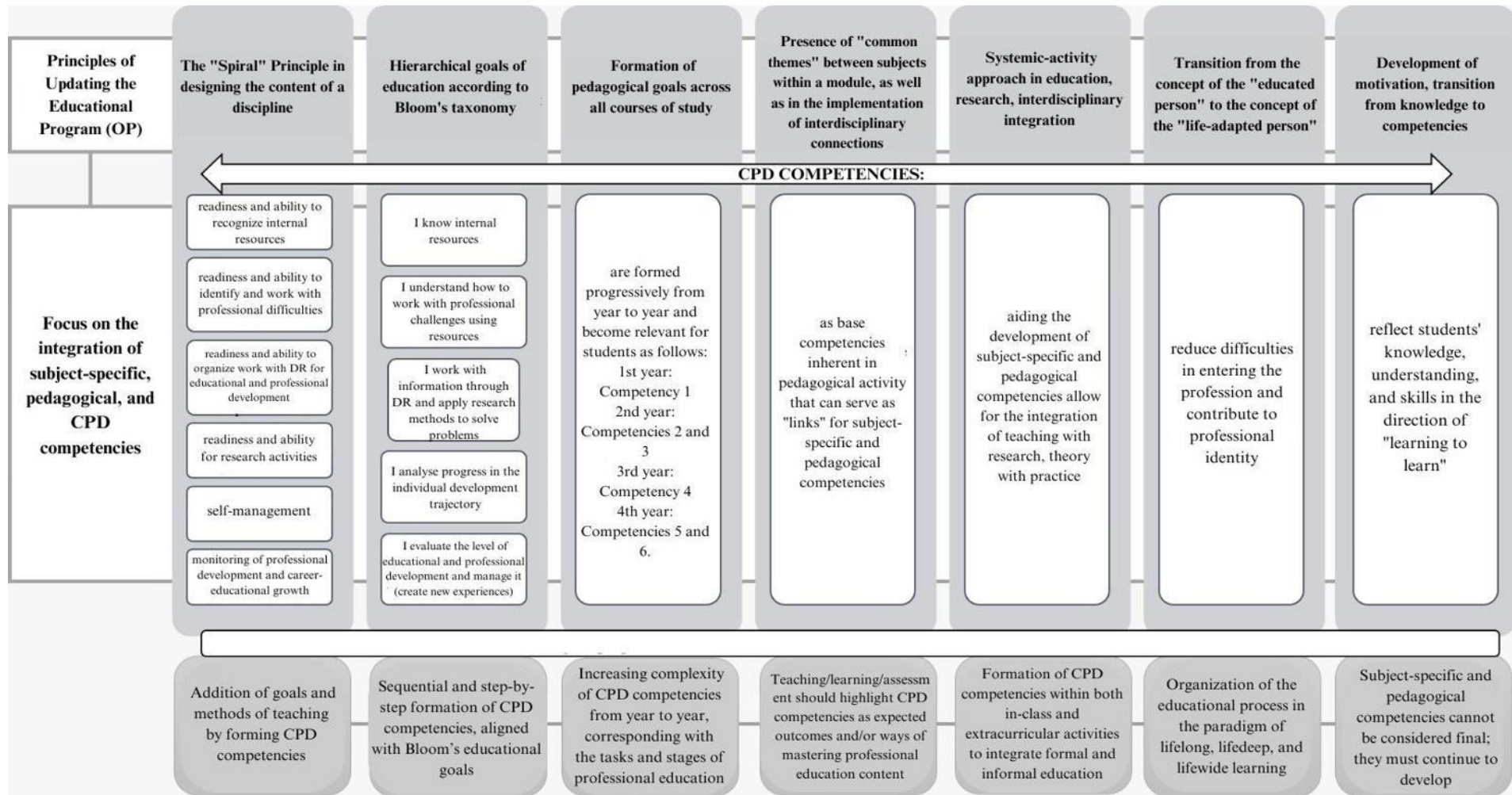
### *3.2. Data Collection Methods*

A questionnaire based on the "Profile of a Graduate" was developed to assess the level of CPD competencies before and after the implementation of meta-learning. The questions included: (1) What do you expect from your own CPD? (2) How do you overcome difficulties in academic and professionally oriented activities? (3) How has your mastery of ICT and artificial intelligence affected your development? (4) How have research competencies influenced your professional development? (5) How do you evaluate your self-management skills in CPD on a 5-point scale? (6) How do you track changes in your professional development? (7) If you were the rector, what would you change at the university for CPD and students' career-educational growth?

To obtain qualitative information about the perception of meta-learning and its impact on professional development, in-depth interviews with qualitative questions were conducted: (1) How often do you apply CPD methods/strategies? (2) What motivated your CPD activity – addressing deficits or enhancing achievements? (3) What emotions accompanied CPD processes? (4) What educational resources did you use – formal, non-formal, or informal? (5) What CPD results do you consider expected, unexpected, successful, or unsuccessful? (6) How would you characterize the "functionality" of your own CPD competencies? The participants of the in-depth interviews (October 2024) were 138 graduates from two universities involved in the study, employed in educational organizations in North Kazakhstan and Karaganda regions as of August 2024, and 205 students from both universities who advanced to their 4th year and enrolled in undergraduate (176) and master's (29) programs starting from September 1, 2024. Both categories had participated in meta-learning over the two semesters of the preceding academic year. For the student category, meta-learning continues in the new academic year, transforming CPD competencies into personal qualities. For the category of novice teachers, meta-learning becomes a relevant experience in the workplace.

The participants, based on the interview results, created their "tree of meanings" for CPD activities, rating the significance of each mastered CPD activity. Each statement of meaning was rated from 1 (most significant CPD activities) to 8 (least significant). In this way, participants identified a hierarchy of personal meanings in CPD. The methodology idea was borrowed from T. Terekhova & Belan [46] and adapted to the conditions of this research. The questions were rated by two experts in CPD. The qualitative data from the survey and in-depth interviews were analyzed using content analysis to identify key themes, and the responses were encoded and processed using Microsoft Excel software. Content analysis allowed the classification of data from individual reflective reports into 8 categories, defining them as categories of CPD meanings: leading (3-9 points), neutral (10-17 points), and ignored (18-24 points).

According to the preliminary informed consent, students' and graduates' participation in the survey and subsequent interview was voluntary and confidential, and they were over 18 years old at the time of the study. The study was approved by the Ethics Committee of Kozybayev University and Buketov University.



**Figure 2.**  
Principles for Updating Educational Programs to Integrate Subject-Specific, Pedagogical, and CPD Competencies.



#### 4. Results

RQ1. Based on the data analysis collected before and after meta-learning (quantitative analysis), what are the dynamics of changes in CPD competencies among pre-service teachers as a result of meta-learning? Let's present the results of the survey before and after meta-learning for each of the survey questions. Before the intervention, 61% of students answered the question, "What do you expect from your own CPD?" in the following way: they indicated CPD as a societal expectation, a tool for professional growth, a required condition for raising the qualification category, and a factor for career and educational growth, interpreting CPD as an activity driven by external demands that align with their future plans. Only 39% of students noted the practical value of CPD processes (strategies) for their current learning, overcoming existing deficits, and improving academic and other achievements.

After the introduction of meta-learning, students' responses showed that 23% of students' answers largely coincided with their pre-meta-learning responses. Meanwhile, 25% of respondents showed a conscious focus on graduate education (with prospects for doctoral studies) for a confident continuation of pedagogical and scientific-pedagogical activities. 73% of students viewed CPD as a tool for transitioning to higher levels of pedagogical activity, toward self-realization in the teaching profession and pedagogical creativity.

When answering the question, "How do you overcome difficulties in academic and professional-oriented activities?", 64% of respondents indicated that they primarily turn to teachers or other students, stating that it is "faster and more familiar", "reliable", and "proven several times". 21% of students preferred using private services, such as tutoring, assignment completion, or writing required work. Only 15% of respondents went beyond external services and formal education, recognizing the value of self-education and self-learning strategies. Thus, the majority of those interviewed did not view overcoming difficulties as a research task to be solved independently through CPD tools.

After the intervention, the results for this question showed that 18% of students demonstrated an expectation of external help to overcome difficulties in academic and professional-oriented activities. 72% of respondents stated that they took responsibility for overcoming academic-professional deficits by independently identifying difficulties, setting goals and tasks, selecting and applying resources and strategies, and reflecting on the effectiveness of their application.

The results of the perception of the impact of ICT and artificial intelligence on CPD showed that 92% of students used information search when preparing for classes and completing assignments. Only 8% mentioned digital technologies and artificial intelligence in the creation of their own product (educational, research, or methodological) as an achievement in professional development. After the introduction of meta-learning, 29% of respondents continued to demonstrate the previous tendency of using ICT for social and educational communication as auxiliary tools for searching, processing, storing, and transmitting information, but not for methods and strategies of research and creative activities or creating an individual style of professional development. 71% of students indicated that, alongside social and educational communication via ICT, they actively used the possibilities of artificial intelligence in mastering educational material and generating products for their own educational-professional development.

In response to the question "How has mastering research competencies influenced your professional development?", 73% of respondents stated that they participate in conferences, Olympiads, competitions, etc. (episodic application), which correlates with the answers to the second question: most interviewees do not view research competencies as a reliable tool for solving professional-pedagogical tasks with an additional long-term effect on students' self-development and self-realization. After the intervention, 12% highlighted the influence of external incentives combined with narrow personal motives for participating in scientific events (obtaining prizes, diplomas, and certificates). 23% consider mastering research competencies as a "philosophy of life" for modern individuals to solve personal, professional, and global tasks; 28% view it as a resource for solving problems in educational practice; and 37% consider it a resource for independently mastering new, relevant, and poorly studied topics.

In response to the question "How do you assess your self-management level in CPD on a 5-point scale?", 19% chose 5 points, 41% chose 4 points, 22% chose 3 points, and 0% chose 1-2 points. 18% were uncertain. Thus, the majority of respondents assessed the self-organization of their professional development at an average level. The reasoning for the score was provided in only 9% of the responses, with specific references to CPD goals, methods applied, and personal resources. After meta-learning, there was a shift in the scores: 28% chose 5 points, 51% chose 4 points, 12% chose 3 points, and 3% chose 1-2 points. 6% of respondents were unsure in their self-assessment. Therefore, 79% assessed the self-organization of their professional development at a high or medium level, adequately evaluating the resources, methods, and strategies used in CPD.

Regarding the question "How do you track changes in your professional development?", it is notable that the vast majority of respondents focus on external quantitative results of academic performance, certificates, diplomas, and published articles. Markers such as "planning", "monitoring", "dynamics", "analysis of results", "external development indicators", and "internal development indicators" did not appear in the answers. 74% of interviewees are unable to perform monitoring of their own professional development, 14% do not know how and do not see the need for it, and 12% do not think about it at all. The intervention changed the nature of the responses: 19% still mention academic performance, the number of publications, material (awards, grants), and non-material rewards (diplomas, certificates) as indicators of CPD dynamics. 13% consider upcoming career and educational growth as an indicator of dynamics. 68% identify monitoring as the leading mechanism for managing their own CPD in the sequence of stages: analysis of the problem situation, goal-setting, resource selection, obtaining results, activity analysis, and decision-making.

In response to the question, "If you were the rector, what would you change in the university for CPD and students' career-educational growth?" before meta-learning, 94% of respondents suggested strengthening the practical orientation of classes, conducting more training based on real-world practices, and allowing students to combine work with study starting

from the 2nd or 3rd year. Interviewees proposed ideas such as a student digital portfolio, teaching and assessment by foreign professors, successful university managers (board members, directors, department heads), and organizing a "Best Student of the Educational Program" competition with the possibility of receiving a grant.

After meta-learning, respondents suggested: forming a talent pool of high-potential staff and faculty from among students and graduate students (15%); ideas to transform the university into an open educational space with the elimination of the authoritarian communication style "student-teacher-administration" (18%); providing students with more academic and research autonomy (23%); transforming the teaching of courses into training in the most effective CPD strategies (24%); and expanding the categories of university stakeholders (20%).

The analysis of data collected before and after meta-learning (quantitative analysis) allowed us to obtain results for the research question: What are the dynamics of change in CPD competencies among future and novice educators as a result of meta-learning? To achieve their own CPD goals, participants became more oriented toward the internal mechanisms of its organization and management, identifying the following as incentives for CPD: motivation for professional self-development and its forecasting, mastery of self-development strategies, and recognition of professional self-development results through the accrual of nano-credits. The data obtained indicates the statistical significance of the results.

The readiness and ability to recognize internal resources for self-development have a more stable character and are explained by respondents as inherent to teachers, forming an integral part of their professional competence. In the structure of readiness and ability to define and address professional difficulties, there is a prevailing tendency for self-definition of professional difficulties through identification and planning work to overcome them. The use of ICT and artificial intelligence is largely driven by personal needs for creating original products and using them as mobile and accessible resources for CPD. Research activity methods are used more frequently and systematically to solve practical tasks in academic and cognitive activities. The focus is on enhancing the strengths of self-development through their application. Self-management competence carries greater weight in CPD activities, which is reflected in the reflection on the use of self-development strategies, the integrated use of informal and non-formal education resources, and the growing exchange of best CPD practices. Monitoring CPD in respondents' activities becomes a recognized need to strengthen strengths and manage personal growth. Respondents increasingly use diagnostic methods to measure changes under the influence of CPD and show a sustained interest in the diagnostic results and correcting CPD processes.

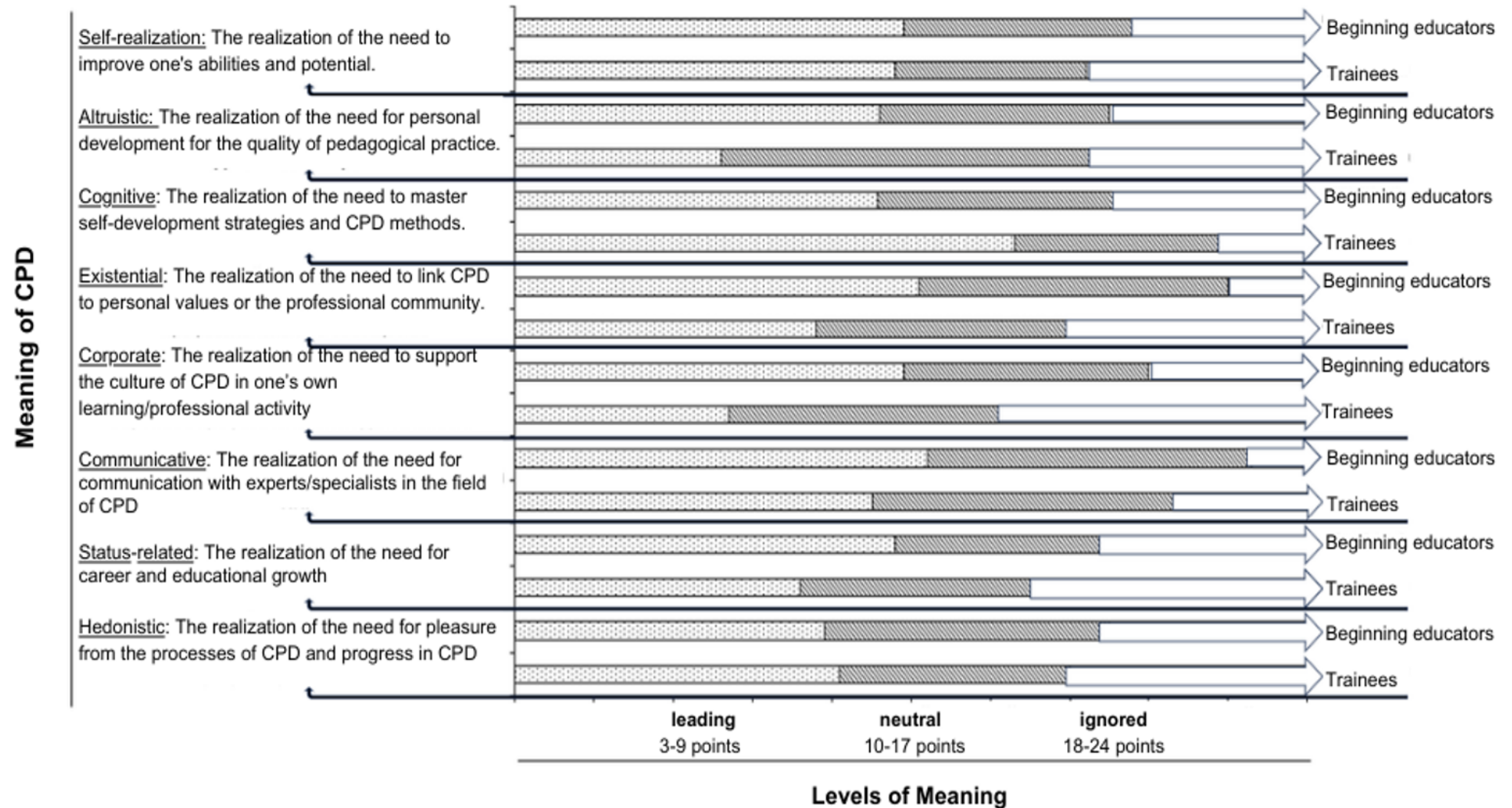
Now, let's turn to the results of the in-depth interview, accompanied by the method of extreme meanings to minimize distortions in the data provided by the participants. Content analysis of in-depth interview materials allowed us to classify the data of individual reflective reports into 8 categories, defining them as categories of CPD meanings: leading (3-9 points), neutral (10-17 points), and ignored (18-24 points). Based on the processing of individual report data, the results are presented in Figure 3.

The analysis of the in-depth interview data (qualitative analysis) provided results for the research question: *RQ2. How do participants describe what they learned during meta-learning, and how did they use the acquired knowledge in their professional development?* The results are as follows.

- The indicators of readiness and ability to recognize internal resources become more significant and are defined by the participants as the meanings of self-realization and cognitive meanings.
- In the readiness and ability to define and address professional difficulties, there is a reliance on cognitive, communicative, and corporate meanings.
- The readiness and ability to work with ICT and artificial intelligence are associated by the respondents with cognitive and hedonistic meanings.
- The readiness and ability to engage in research activities are represented in categories of corporate, existential, and status meanings.
- Respondents assign status, corporate, and altruistic meanings to self-management.
- Monitoring professional development and career-educational growth holds status and hedonistic meanings for the participants.

The final diagnosis of the meaning-definition of CPD competencies confirms the direction of meta-learning towards: forming pre-service teachers' readiness to solve professional tasks (motivational aspect); expanding professional opportunities (instrumental aspect); qualitatively changing oneself as the subject of activity (value-meaning aspect); professional development (processual aspect); adapting to changing requirements of professional competence (behavioral aspect); and increasing individual-personal and professional experience for teachers in the direction of promising, forward-looking, ambitious, and forward-thinking (worldview aspect). The statistical significance of the results obtained is confirmed by establishing a multidirectional relationship between meta-learning and CPD competencies, and the impact of this relationship on changes in the personality structure of future teachers in the direction of adaptation to the increasing complexity of professional conditions.





**Figure 3.**  
Content Interpretation of CPD Activity Meanings.

## 5. Discussion

The interpretation of the survey results before and after meta-learning confirms the importance of competency-based learning in the context of managing CPD [45]. In forming the readiness and ability to recognize internal resources for self-management in CPD, students at the goal-setting stage of each lesson highlighted CPD goals, determined by the topic and its complexity, as well as the appropriate resources from informal and non-formal education that answered the question "how to better master the topic." Conceptual judgments of authoritative authors on self-development strategies were taken as the basis.

Forming the willingness and ability to understand internal resources for organizing self-management of CPD, students at the goal-setting stage of each lesson identified the goals of CPD, determined by the topic and the complexity of its development, suitable resources of non-formal and informative education, answering the question "how best to master the topic." It was based on the conceptual judgments of reputable authors on self-development strategies, since meta-learning is value-semantic. The students' specific and clear definition of the goals of CPD, consistent with the values of the assignments, contributed to the formation of an individual learning style and academic achievements based on it. This logic of development was established in a study of the educational activities of 108 Mexican students to identify the relationship between the regulation of the value of tasks and learning style [46].

To develop monitoring skills for CPD, descriptors of current assessment were introduced, which clarified the manifestation of CPD. This approach contributes to the development of students' literacy in evaluation, motivating them for holistic learning Lokman et al. [47], and implements flexible formative assessment to elevate students to a higher metacognitive level [48]. For example, for the practical session "Boundaries of Pedagogical Tolerance," descriptors were developed based on the "CREMI" strategy (creativity, reflection, effectiveness, motivation, initiative) [49]: 1) I confidently generate creative ideas, 2) I analyze my own experience, 3) I optimally organize time, thoughts, and resources, 4) I visualize the expected result, 5) I translate cognitive motives into educational initiatives.

For conscious self-development management, students formulated personal meanings and values, which are necessary for the sustainable, motivated development of self-regulated and self-directed learning. For example, discussing the main idea of a book, Peterson and Colb [50] students decided to sequentially test each of the 9 learning strategies. At the end of the course, through Storytelling, they justified the practical value of the strategies in terms of competency in dealing with difficulties in professionally oriented activities.

For guiding research activities in their own CPD, students in the course "Research and Project Activities of a Teacher-Psychologist" studied a project by Qanai et al. [51], and presented their understanding of the key question: "Can non-positional leadership of teachers influence the reform of Kazakhstani education?" using the PRES-formula (Position - Reason - Explanation/Example - Summary). Then, in a post scriptum genre, they answered the question, "What research skills have I reinforced through completing this task?"

Meta-learning research skills enable students to identify internal and external resources to transition from learning to research-based problem-solving. Meta-learning makes it possible to make cognition of internal resources, planning work with professional difficulties, self-management, and monitoring of CPD personally significant. Thus, the mastery of subject-pedagogical content is achieved through personal practice, which expands the boundaries of cognition and attracts metacognitive strategies. Tasks in the course "Cultural-Historical and Activity-Based Approaches in Psychology and Education" (Master's program in Pedagogy and Psychology, 1st year) addressed the exploration of internal resources, planning work with professional difficulties, self-management, and monitoring CPD. For example, on the topic "Personality as a Psychological Category," students completed the task: "Explain how the manifestations of CPD competencies reflect the criteria for the formation of personality." For the topic "Activity as a Psychological Category": "What specific types of activities do you engage in for your own professional development on: a) a regular, systematic basis, b) episodically, c) rarely? What can explain this hierarchy of activities? Which CPD competencies are motivated by a) goals, b) multiple motivations, c) unconscious motives? Provide examples from your own CPD practice."

The qualification projects of the students of the final year of the program "Pedagogy and Psychology" are related to the study of CPD processes in educational and professional activities, for example, scaffolding pre-service teachers-psychologists for sustainable motivation for self-development and self-realization in the educational environment of the university. Self-development constructor for pre-service teachers in creating original methodological products. Action project for professional self-development of pre-service teachers-psychologists based on team-building strategies. Resource support for pre-service teachers-psychologists for a smooth entry into the profession.

The practice of project implementation and defense supports the academic independence of students within the CPD ecosystem, as project work focuses on mastering CPD competencies and the "learn to research" strategy, supports solving problems in teams, connects with expert educators, and creates original products, including through interaction with ICT and artificial intelligence. This approach to organizing research activities confirms the importance of concrete student actions to solve contextual problems [52].

Meta-learning synchronizes components of the educational process toward self-regulated learning, where the availability of CPD resources fosters proactive learning for students [53].

- Teaching methods, including overcoming difficulties by using resources from formal, non-formal, and informal education.
- Learning - reflection and feedback on the effectiveness of applying self-development strategies.
- Evaluation (current, interim, final) - defining CPD criteria and descriptors for them.
- Let's summarize the characteristics of meta-learning that constitute the technological resources of modern higher education (project-based, intellectual, event-based education) [54].

- Using students' perceptions of cognitive development possibilities/barriers as didactic material.
- Stretch assignment tasks with controlled cognitive tension through scaffolding.
- Competency-based learning for working with problems and risks using individual thinking and activity strategies.
- Contextual learning for solving pedagogical practice problems through innovative approaches, educational initiatives, and reforms.
- Expanding the growth mindset towards critical, innovative, and adaptive thinking.
- Team building to create a collaborative interaction environment that "cultivates" growth mindset thinking.

These characteristics of meta-learning will be more productive in the context of socio-emotional learning. It requires the use of technologies for this visible learning that support not only feedback, but also the performance of students' achievements, as the researchers confirm [55].

Meta-learning with the goal of CPD enables interaction between academic, professional, and meta-skills, expanding and deepening subject-pedagogical learning toward metacognition and meta-learning, supporting pre-service teachers in their professional identification, and expanding the rights and opportunities of novice teachers.

The result of integration is metacognitive thinking, which is "necessary for continuing education and adapting to new situations," and metacognitive maturity implies knowing what one wants to achieve and how to achieve it [56].

The results of the study provide answers to the research questions. *RQ1: Meta-learning influenced the change in CPD competencies: their application in students' academic and research activities became more motivated and systematic, as an expression of self-care.* The goals of applying CPD competencies expanded: from understanding and using them to analyzing their impact on academic achievements and professional development, designing individual activity styles, and evaluating internal and external resources for development. *RQ2: Pre-service teachers and in-service teachers, through meta-learning, learned reflective analysis of internal development resources, identifying learning and professional difficulties, and working with them based on the resources of non-formal and informal education.* They applied digital transformation tools in education to create their own products, integrated research into learning and pedagogical practice, and searched for, selected, applied, and evaluated CPD forms and methods. They also identified strengths and weaknesses in the observed behaviors within CPD. Students used the knowledge and skills acquired not only for academic purposes but also for professional development. Beginning teachers began to use the knowledge and skills to design their career and educational growth trajectory.

The results of the study should be used in the development of educational programs for teacher training, including CPD competencies in expected results, CPD methods, and strategies in support of course development. Teachers can expand the research results by achieving the transformation of self-development strategies into CPD technology. Experts in the quality of teacher education need to refer to the competence of the CPD as a tool for transforming vocational education into continuing professional education. In general, education policy should take into account the CPD as a methodology for improving the quality of teaching activities in the direction of the achievements of both teachers and students.

This study is not without limitations. First, the reliance on reflective reports in constructing the "tree of meanings of CPD activity" raises concerns about the depth of the collected meanings. Although the reflective report is a common and practical method in research, it inherently relies on the subjective perception of the participants, which may not fully reflect the complexity of their understanding of CPD. Second, the research methodology, which includes only two measurement points, offers a limited temporal perspective. This design provides a valuable snapshot of students' changes under the influence of CPD but does not capture the continuous evolution of professional development when transitioning from the learning environment to the teacher's workplace. The dynamic nature of CPD processes and activities in the reformed education system requires more frequent observations to accurately track and understand these changes. Third, an analysis of the factors that facilitate or hinder the successful integration of meta-learning into pedagogical programs in Kazakhstani universities is needed.

Additionally, this study did not delve into specific details such as the classification of CPD methods and strategies, and the preferences for their selection, or the frequency of use of non-formal education resources compared to informal ones. This omission leaves a gap in our understanding of how students integrate CPD resources and to what extent this influences their academic and other achievements. These limitations emphasize the need for future research with more detailed data collection methods, including upgrading teacher training programs, observing CPD in the teacher's workplace, and monitoring the impact of CPD on academic and other achievements of students, as well as the career-educational growth of the teacher. Future research should focus on bridging these gaps, possibly by including longitudinal projects with multiple data collection points and detailed studies of the structure and complexity of CPD competencies for professional-pedagogical identification in the education system, in order to prepare for the complex world of managing one's own CPD during education and at the workplace. This approach will provide a more comprehensive and accurate depiction of CPD processes and activities in the education system.

## 6. Conclusion

The results of the longitudinal study showed that the implementation of meta-learning significantly enhances competencies related to continuous professional development among students from Kazakhstani universities. Participants in the study demonstrated a notable increase in their understanding of the importance of self-development and autonomous learning, as evidenced by their changing attitudes toward the professional preparation process. Meta-learning not only contributes to the formation of necessary competencies but also encourages students to actively utilize information and communication technologies, as well as develop research skills. This, in turn, lays the groundwork for improving the level

of professional readiness of future educators to adapt to changes in the educational environment. An important aspect is the need to integrate meta-learning into educational programs, which will ensure a deeper preparation of students for the modern demands of the profession. Further research could focus on assessing the long-term effects of meta-learning and examining its impact on the career development of graduates. Thus, meta-learning represents a promising approach that can significantly enhance the training of future teachers and their ability to engage in continuous professional growth in a rapidly changing educational landscape.

For researchers, it is essential to conduct further longitudinal studies to assess the long-term effects of meta-learning on the professional development of educators beyond initial training phases. Additionally, exploring the implementation of meta-learning across diverse educational contexts and cultures will provide insights into its adaptability and effectiveness in various settings. A mixed-methods approach, combining quantitative surveys with qualitative interviews, is encouraged to gather comprehensive data and deeper insights into participants' experiences. Researchers should also investigate how meta-learning influences career trajectories and opportunities for graduates in the education sector, including job placement and advancement. Finally, developing and evaluating specific strategies for integrating meta-learning into teacher training programs will be crucial for assessing its effectiveness in enhancing educational outcomes.

For practitioners, integrating meta-learning principles into teacher education curricula is vital, emphasizing skills such as self-regulation, autonomous learning, and the effective use of technology. Organizing professional development workshops for current educators will familiarize them with meta-learning techniques and their application in the classroom. Fostering collaborative environments where pre-service teachers can engage in peer learning and share best practices related to meta-learning strategies will enhance their learning experience. Establishing regular feedback mechanisms for students to reflect on their learning processes and outcomes will promote continuous improvement in their professional development. Lastly, providing resources and support for students to explore various learning modalities – formal, non-formal, and informal – will enhance their competence in self-directed learning.

This study has limitations. First, the reliance on reflective reports in constructing the "tree of meanings of CPD activity" raises concerns about the depth of the collected meanings. Although the reflective report is a common and practical method in research, it inherently relies on the subjective perception of the participants, which may not fully reflect the complexity of their understanding of CPD. Second, the research methodology, which includes only two measurement points, offers a limited temporal perspective. This design provides a valuable snapshot of students' changes under the influence of CPD but does not capture the continuous evolution of professional development when transitioning from the learning environment to the teacher's workplace. The dynamic nature of CPD processes and activities in the reformed education system requires more frequent observations to accurately track and understand these changes. Third, an analysis of the factors that facilitate or hinder the successful integration of meta-learning into pedagogical programs in Kazakhstani universities is needed. Additionally, this study did not delve into specific details such as the classification of CPD methods and strategies and the preferences for their selection, or the frequency of use of non-formal education resources compared to informal ones. This omission leaves a gap in our understanding of how students integrate CPD resources and to what extent this influences their academic and other achievements. These limitations emphasize the need for future research with more detailed data collection methods, including upgrading teacher training programs, observing CPD in the teacher's workplace, and monitoring the impact of CPD on academic and other achievements of students, as well as the career-educational growth of the teacher. Future research should focus on bridging these gaps, possibly by including longitudinal projects with multiple data collection points and detailed studies of the structure and complexity of CPD competencies for professional-pedagogical identification in the education system, in order to prepare for the complex world of managing one's own CPD during education and at the workplace. This approach will provide a more comprehensive and accurate depiction of CPD processes and activities in the education system.

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