The System of Future Teachers' Professional Development

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Abstract: The article aims to theoretically justify, develop and experimentally verify the author's model for implementing the system of future teachers' professional development as a requirement for professional training of future specialists. The objectives of the article are the following: to identify structural components of future teachers' professional development; to develop and experimentally verify the effectiveness of the model of future teachers' professional development; to determine pedagogical conditions for its implementation. Research methods include theoretical analysis and generalization of relevant scientific-methodical literature; pedagogical observations; monitoring of future teachers' levels of professional development and readiness for it; modelling; pedagogical experiment; methods of mathematical statistics. The value of the obtained results lies in defining and justifying the structure of future teachers' professional development theoretically, as well as verifying the modelled system of future teachers' professional development and pedagogical conditions for its implementation experimentally. Besides, one can observe a significant increase in the levels of future teachers' professional development in the experimental group. Conclusions: the article shows that the system of future teachers' professional development, which is implemented through the experimental model and whose goals, content, methods, tools and technologies are aimed at achieving effective results, enhances the level of future teachers' professional development and their readiness for it.

Keywords: *professional development, readiness for professional development, future teachers, model, system.*

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1. Introduction

Nowadays, the process of developing competencies is rather relevant since they imply one's capacity for continuing professional development as a necessary criterion for the quality of professional training. Personal development is seen as the highest form of conscious self-development, an opportunity for personal growth and a striving for a certain ideal (Paranthaman et al., 2019). Zellma (2015) indicates that teachers' efficient performance of their professional duties is the result of professional training. Also, it serves as their commitment to professional development through self-study.

The analysis of relevant scientific literature shows the multifaceted nature of the issue of professional development. Indeed, Paranthaman et al. (2019) make attempts to define the content and significance of future teachers' self-development as a factor in personal development and consider education and self-study as the leading components of self-development. Zellma (2015) also emphasizes the essential role of self-study and self-education in preparing teachers for professional growth. Sebalo and Teslenko (2020) devote their study to self-development and self-improvement of future physical education teachers through self-study. They identify modern organizational forms of teachers' educational activities, among which they prioritize the project method, case studies and portfolios.

Pavliuk et al. (2017) justify the components of professional development of physical education teachers and the criteria for their assessment. The authors developed a pedagogical technology aimed at professional development of physical education teachers, determined and experimentally verified the effectiveness of pedagogical conditions for the implementation of the technology. These conditions include considering individual and age characteristics of teachers; motivating them towards self-development in the process of professional activities; providing them with the opportunity to come up with their own trajectory of self-development, taking into account the guidelines on professional development.

Sela and Harel (2019) offer some practical recommendations for schools and educational institutions in terms of novice teachers' development. Sincar, Önen, and Arar (2020) justify the views of Turkish school administrators on the concept of self-development and the methods they use in the process of their self-development.

Yarmakeev et al. (2019) highlight the links between internal motivation and professional development of teachers which reveal theoretical provisions of self-development and motivation towards

professional development, its structure, criteria and tools. Lejonberg et al. (2018) indicate some positive links between mentoring and self-development.

Following the self-determination theory, Zhou, Mao, and Tang (2020) study the antecedent, consequences and boundary conditions of learning from failures as a means of employees' enhanced self-development. According to Kanaoka (2011), the language instruction which organically integrates identity, inner spirituality, relevant practice and self-expressive of L2 use leads to successful self-development of students. Yazan (2018) believes that using the concepts of identity and agency can largely contribute to self-development of teachers.

Belenkova (2020) emphasizes the positive role of metacognitive skills and reflection in cognitive activity based on self-study strategies. Besides, she justifies pedagogical conditions which are essential to develop metacognitive skills and reflection in students. Kniazian and Khromchenko (2019) study the issue of developing self-development competency in ESP lecturers in the context of higher education. López and Aguilera (2019) prove that ICT is an effective means of self-development for both students and teachers. Zhang (2020) highlights the need to synergize Internet resources and professional linguistic knowledge of English teachers to overcome those problems which may occur in the process of self-development. Juggernath and Govender (2020) indicate the leading influence of internal factors (beliefs) on the effectiveness of using ICT in the activities of science teachers. External factors, however, play only a secondary role. The study by Pashkevych, Yezhova, and Gerasymenko (2020) is devoted to the use of ICT, in particular, Internet resources and mobile applications, in the self-education of designers.

Although there are many scientific papers on various aspects of issues similar to that under study, Giles (2018) indicate the insufficient level of self-study skills as the basis for self-development. Besides, Syunina et al. (2018) point out to the need to find some effective ways of preparing future teachers for professional and moral self-development during their professional training in universities. The authors of the article believe that the objectives of future teachers' self-development are not sufficiently disclosed in the context of new paradigms in the development of education. In this regard, it is essential to develop an effective system of future teachers' professional development in higher education.

2. Material and methods

2.1. Study participants

The study was carried out at the Natural and Geographical Sciences Faculty of Volodymyr Vynnychenko Central Ukrainian State Pedagogical University between 2014 and 2019. It involved undergraduate students majoring in "014 (Secondary Education) Chemistry" and "014 (Secondary Education) Biology", as well as graduate students pursuing master's degrees in "014 (Secondary Education) Natural Sciences" and "014 (Secondary Education) Biology". The experiment involved 401 students and 5 university teachers. It was organized under the same conditions for all its participants. Indeed, experimental work was rather prolonged in time and involved monitoring, which made it possible to adjust the course of the experiment and the conditions under which it was conducted. Both control (CG – 200 students) and experimental (EG – 201 students) groups consisted of future science teachers. All participants gave informed consent to be involved in the experiment. Ethical standards for study participants were met. The students who were pursuing degrees regularly changed and, therefore, it was impossible to experiment with them twice, i.e. with the use of an active factor and without it. With this in mind, a parallel experiment was conducted. It involved two objects homogeneous in indicators, namely, experimental and control groups. CG students were trained based on the traditional system of training, whereas EG students followed the developed methodology. The conditions of the experiment were created to ensure the stability of all factors except those under study in terms of the validity and reliability of experimental data. The results of the study were approved by the decision of the Academic Council of Volodymyr Vynnychenko Central Ukrainian State Pedagogical University.

2.2. Theoretical principles of motivating future teachers towards professional development

The analysis of relevant literary sources allows one to define the multifaceted concept of "professional development", which is viewed as the essence, activity and process. In turn, it makes it possible to define future teachers' professional development as some independent and integrative activity conditioned by socio-pedagogical requirements for the profession. Its structural components are self-realization (one's need to realize one's potential), self-study (one's need to improve professional knowledge, skills and abilities) and self-cognition (one's need to compare one's abilities with professional requirements). As a process, it implies the interdependence of

self-management and management in the context of the educational process. Being a result, it reflects future teachers' readiness for professional development. The links and interactions between structural components of future teachers' professional development create a stable system constituting professional development.

In this article, future teachers' professional development is viewed as a separate sub-system in the structure of a more general system, that is professional teacher training. The author's system of future teachers' professional development consists of three logically connected blocks. They are concepts and goals, organization and content, assessment and results (Figure 1). These blocks involve the aim, objectives, methodical approaches, principles, content, forms, technologies and methods of teaching and learning, pedagogical conditions and diagnostic tools for identifying professional development levels, as well as the main result (future teachers' readiness for professional development).
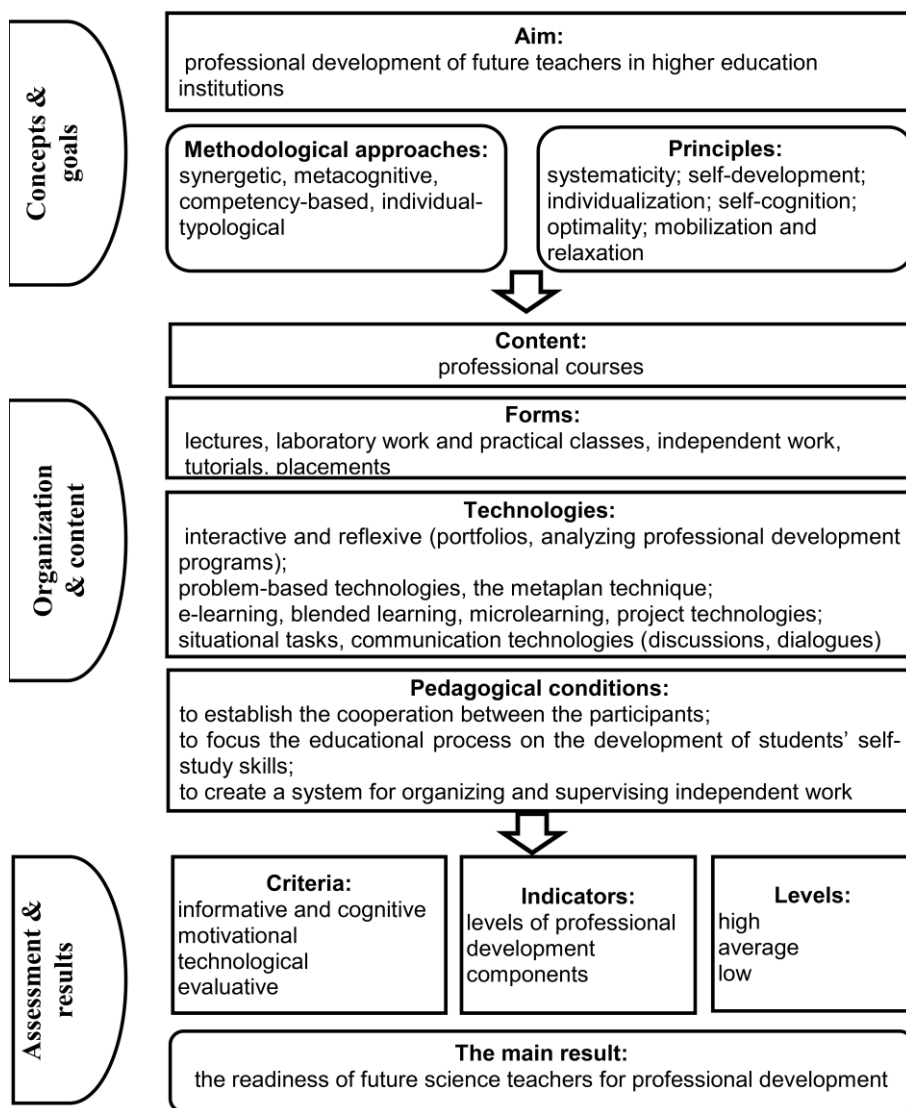
Fig. 1. *The model of the system of future teachers' professional development*

Source: The result of the author's analysis

The proposed model of future teachers' professional development is based on the following principles:

−systematicity involves coherence and integrity of the educational process;

−self-development is based on such pillars as the transition of development into self-development and management in self-government;

−individualization proves the expediency of focusing on the development of students' traits;

−self-cognition assumes that any activity should begin with an analysis of one's strengths and weaknesses since one can rely on strengths and improve other traits in the future;

−optimality implies one's ability to find some optimal ways to achieve professional goals, use time wisely and rationally;

−mobilization and relaxation include not only defining serious tasks but also distributing one's forces on the path to achievements.

The following approaches are defined as methodological principles of developing the model of future teachers' professional development:

−a synergetic approach allows one to shape a holistic approach to professional training and take into account the dynamics and mechanisms of self-organization of the actors in the educational process; it unites the goals, content, forms, methods, innovative methodologies and technologies of future teachers' professional development, given that the fundamental component of the synergetic paradigm is the principle of self-organization of a complex system);

−a metacognitive approach contributes to developing metacognitive knowledge (stable, modifiable and conscious knowledge based on verbalization and created taking into account previous experience), as well as promoting and expanding the range of metacognitive strategies; the country's need for future teachers who are ready for professional development;

−a competency-based approach ensures the development and improvement of professional-pedagogical knowledge, skills and professionally important qualities; it also enhances the competency-based experience of self-study activities in students who strive for professional development, as well as the position of the real subject of the future profession);

−an individual-typological approach cultivates students' values-based attitude towards independent work and professional development due to optimal management of independent work, taking into account their individual and typological features.

The organization and content block includes the content, forms, methods, tools and technologies of future science teachers' professional development. The model represents the content through the implementation

of syllabi of professional courses. The content-related component requires the appropriate ratio between fundamentalization and professionalization of educational material by clarifying its links with syllabi in secondary schools, structuring educational material, detecting duplication and continuity of educational material at the interdisciplinary level. In such a way, students will be aware of the need to learn in terms of future professional activities and, thus, will be able to boost their motivation towards learning.

The mentioned model can be effectively implemented with the help of didactic technologies covering forms, methods and techniques of teaching and learning by modelling the ways of acquiring educational material within a particular course, topic or issue used in professional training and adapted to the subject of this study.

It must be noted that the model can be implemented during lectures, laboratory work and practical classes, placements, independent work. In turn, it enhances the effectiveness of developing motives for professional development, helps students realize the importance of self-cognition, self-actualization, self-realization and self-study during classroom and extracurricular activities.

The modelled system of future teachers' professional development involves creating typological groups of students, allowing them to change groups based on their progress and learning capabilities and developing individually differentiated tasks for independent work. Also, it implies combining frontal, group and individual work of students and creating an atmosphere of the joint creative experience. It includes using innovative technologies of teaching and learning (technologies of personal development, as well as those enhancing learner autonomy, an active life position and a sense of responsibility; modelling technologies (business games and situations); communication technologies (discussions, dialogues); interactive and reflective technologies (portfolios); problem-based technologies which develop students' creative skills, promote research activity and improve divergent thinking; technologies of intellectual activity (the metaplan technique which creates conditions for self-realization); innovative technologies (e-learning, blended learning, microlearning); project technologies. Finally, it enables the systematic individual assessment of the process and results of self-study activities and develops self-study skills as a personal quality by reaching higher levels of self-study activities.

The introduction of traditional and innovative technologies (project technologies, ICT, portfolios) and teaching methods has made it possible to create a system of multilevel tasks (generative, research-related, creative). Using them can increase the level of professional development, namely, self-

study skills: independent work aimed at enhancing analytical skills, self-organization, self-control and self-assessment.

The assessment and results block determines the main aim of the model, that is to develop future teachers' readiness for professional development. Positive dynamics in their levels of professional development and appropriate readiness is expected to be the main result obtained from implementing the system of future teachers' professional development.

The level of professional development can be explained by certain criteria and components. The criteria have certain indicators that correspond to the level of future specialists' professional development.

The motivational and axiological criterion describes future teachers' values-based attitude towards self-development, as well as their awareness of its importance for professional activities and self-realization. The motivational component of future teachers' readiness for development is influenced by their attitude towards professional activities, personal qualities and perception of norms and values. The indicators of this criterion include one's awareness of the significance of development and motives for development (cognitive, professional, success-related) in terms of efficient performance, self-realization, self-actualization and self-motivation.

The informative and cognitive criterion allows one to assess the aim, essence and content of professional development, methods and techniques of rational projection of self-study activities, as well as the features of its implementation in the pedagogical activity. Its indicators are as follows: knowledge of basic terms, principles of professional development and mechanisms of its implementation; knowledge of basic forms of self-study activities and information technologies in the professional activity of future science teachers; theoretical and pedagogical knowledge in the field of professional development; professional-pedagogical knowledge.

The technological criterion is a set of actions, techniques and methods aimed at achieving the goals of development. These goals imply one's ability to define and perform tasks of professional development, select and process information, plan and organize independent cognitive activity and implement the obtained results in professional-pedagogical activity. The indicators of this criterion include one's ability to search, analyze and process information; plan and organize independent cognitive activity; analyze and plan goals, content and results of professional development; choose the most effective ways of professional development; work in a team; independently study the opportunities for professional development; find new ways to solve problems.

The evaluative criterion proves one's capacity for qualitative analysis of self-study activities and promotes the use of methods and techniques of development. Also, it helps one to control and regulate self-study activities, assess its results and make corrections. The indicators of this criterion involve the levels of one's skills in self-analysis, self-evaluation, reflectivity, abilities to compare the obtained results with the planned ones, find mistakes independently, adequately evaluate the results of one's activities.

The above-mentioned criteria and indicators, as well as the developed structure, have made it possible to determine the levels of future science teachers' professional development (low, average, high).

A low level of professional development means that students' professional and cognitive motives for learning are poorly developed. Besides, they lack motivation for success. They are passive and have a vague understanding of educational material. Their professionally important volitional qualities are insufficient, which is manifested in the inability to motivate oneself towards the effective activity. Professional knowledge, as well as knowledge of professional development, is partially developed. As a result, they are not focused on the development of readiness for professional development. Students' knowledge of self-study activities is rather sparse. At the same time, cognitive creativity is almost absent. Such students follow the algorithm, acting as performers, while the university teacher outlines the limits of information retrieval. Also, they do not participate in scientific research, seminars and experience certain difficulties in performing tasks during placements. They do not have individual programmes of professional development. Their skills in self-control, self-assessment, self-analysis, reflection, self-correction and self-criticism are quite poor.

An average level of professional development consists of sufficiently developed cognitive motives, motives for success and high work capacity. The levels of professionally important volitional qualities are quite sufficient. However, they are rather unstable, which indicates a lack of stability in overcoming obstacles. Professional knowledge, as well as knowledge of professional development, is somewhat general. Students have a good understanding of educational material, strive for professional development and develop their techniques and skills in it. Their cognitive activity is constant. Indeed, they seek to participate in scientific competitions and conferences. The products of educational activities are presented in the form of a textual unity containing provisions and conclusions as a result of analytical processing of the information used. In the course of teaching placements, students use their professional skills under supervision, although with some elements of creativity. They implement individual programmes of

professional development with the support of university teachers. However, they do not always do what is expected of them. It must be noted that they are not quite aware of how to develop self-study skills as a means of professional development. Moreover, they employ reflection and self-correction unsystematically. The level of their self-esteem is quite adequate.

A high level of professional development lies in well-developed cognitive and professional motives, as well as motives for success, which is the basis of effective activity and high levels of professional competency. Students' volitional qualities are well developed, too. Their emotional self-regulation is uniform and stable. Professional knowledge, including knowledge of professional development, is holistic and systematic. They have a good command of educational material. Also, they are active in terms of cognition and creativity (winning prizes in competitions, taking an active part in research, conferences). They have a deep understanding of the essence and importance of self-study activities in developing readiness for professional development. Such students demonstrate well-developed techniques and skills in professional development. In the course of teaching placements, they freely transform skills into different activities. The products of educational activities are distinguished by the presence of a problem and a logical statement aimed at its solution. Besides, students can creatively implement individual programmes of professional development based on positive motivation. They constantly enhance their skills in self-actualization, self-cognition, self-study and self-realization and are guided by clear life principles. Finally, they can adjust their activities, adequately assess the results of their activities and use reflection.

Importantly, all these levels are interconnected. They may have intermediate positions, and each previous level is preparatory concerning higher ones.

The last but not least component of the assessment and results block is the main result, that is future teachers' readiness for professional development. In this article, it is defined as an integrated personality trait developed during professional training. It reflects the development of motivation and striving to realize one's needs − the motivational component; professional knowledge (universal scientific, psycho-pedagogical, subject-specific and special), skills (diagnostic, projective, constructive, analytical, research-related and communicative) − the cognitive and activity-related component; skills in self-analysis, self-assessment and reflection − the reflexive component. The main function of all components lies in developing readiness for professional development. The concept of

"readiness for professional development" can be justified through the concept of "professional development". It allows one to identify the compliance of their structural components. Indeed, the motivational component of such readiness corresponds to self-actualization as a component of professional development, the cognitive and activity-related to self-study and the reflexive component to self-cognition.

Thus, all the components of the author's model, as well as their content-related and procedural meanings, are interconnected and shape a holistic pedagogical system aimed at achieving the objectives outlined in the study. The model can be implemented under the following pedagogical conditions: establishing the cooperation between the actors in the educational process based on pedagogical facilitation; focusing the educational process on the development of students' self-study skills; creating a system for organizing and supervising independent work of future science teachers with the use of innovative technologies.

The introduction of the model in higher education institutions can help to develop students' self-study skills. This process includes introductory lessons, which seek to solve the following tasks: to consolidate theoretical and practical training in university teachers and students through the intellectual inversion; to enable university teachers to correct the existing programme of students' development which should correspond to their individual and typological features.

Therefore, the implementation of the author's model involves focusing the educational process on independent work of students (a complex system realized under educational goals), identifying prospects for students' personal development and mastering metacognitive strategies of development, which contribute to shaping and developing individuality.

2.3. Experiment procedures

The experiment involved consulting and providing university teachers with the necessary materials, such as methodological textbooks with theoretical and practical information for the implementation of the educational process. They include the following: "Recommended practice for independent work within such courses "Methods of Synthesis and Analysis of Biologically Active Substances", "Tasks and exercises for classroom and independent work in Biological Chemistry", "Recommended practice for the organization of students' independent work with chemistry teaching methods", "Instructional and methodical materials for students' independent work and individual tasks to prepare for modular assessment

within the course "Analytical Chemistry", "The chemical analysis methods module", The titrimetric analysis module".

The authors of the article have managed to ensure pedagogical facilitation of future science teachers' training. First, they studied individual-typological features of students and divided them into groups. Next, they developed recommendations for the organization of independent work for each group. After that, they advised students on the importance of professional development, ways of improving self-study skills and developing professional development programmes.

Experimental work was conducted following the developed and justified methodology. The experimental programme included assessing the effectiveness of the current methical system of training future teachers by identifying the levels of structural components of readiness for professional development (motivational, cognitive and activity-related, reflexive), which correlate with the components of professional development and by processing the obtained results mathematically.

At this stage, it was vital to identify initial levels of teacher students' professional development, as well as the levels of their readiness for it. They imply the development of professional and cognitive motives, motives for success, self-actualization, cognitive skills, reflexive skills, analysis skills. The following interpretive theoretical and empirical research methods were employed: interviews, conversations, surveys of teachers and students; analysis of products of educational activity.

The indicators of the motivational component were assessed using Rean's test "Analyzing Motivation for Learning" and survey "Motivation to Succeed and Fear of Failure" (Rean, 1994). It became possible to find whether students strived for self-actualization based on the self-actualization test (CAT) (Ilin, 2012). One of the features of this technique is its variability. Depending on the goals of the study, this test can be interpreted in part or in full. Besides, it was essential to analyze the links between students' levels of self-actualization and capacity for professional development. Given this, the study takes into account the results on basic scales only.

The indicators of the informative and cognitive criterion were verified with the help of data on students' progress (the levels of students' command of educational material are calculated as the arithmetic mean of data on students' progress in academic courses, as well as the levels of their knowledge about professional development identified with appropriate surveys). Students needed to answer the questions about both the aim and role of self-development in professional activities (yes, rather yes, rather no, no). The indicators of the technological criterion were studied with the help

of the author's survey. It involved students' self-assessment of their professional development skills (diagnostic, analytical, projective, constructive, research-related, communication) and cognitive and creative activity (well-developed, partially developed, underdeveloped). The average results of informative and cognitive and technological criteria show the levels of the cognitive and activity-related component of future science teachers' readiness for professional development.

The indicators of the evaluative criterion correlating with the reflexive component were determined with the help of Kazantseva's questionnaire "Studying Self-Assessment, Self-Analysis, Self-Criticism of the Individual" (Ilin, 2012).

The reliability of the results, as well as the verification of homogeneity of two empirical samples (in CG and EG), involves using Pearson's chi-squared test (χ^2).

3. Results

EG and CG were created on the distribution of students by levels of their progress at the beginning of the pedagogical experiment. The results of students' semester assessment are selected as indicators (Table 1).

Table 1. Using Pearson's chi-squared test to compare the distribution of CG and EG students by levels of their progress

Levels of progress	Distribution frequency in CG, f_{e1}	Distribution frequency in EG, f_{e2}	$(f_{e1} - f_{e2})$	$(f_{e1} - f_{e2})^2$	$(f_{e1} - f_{e2})^2 / f_{e2}$
Low	90	88	2	4	0.05
Average	86	91	-5	25	0.275
High	24	22	2	4	0.18
Total	200	201			0.505

Source: The result of the author's analysis

Pearson's chi-squared test (χ^2) was used to statistically justify the absence of differences between the distribution of CG and EG students by levels of their progress. The critical value of χ^2_{cr} was calculated using the table of critical values for the number of degrees of freedom $\nu = k - 1 = 2$, where k is

the number of digits (k=3 here). The critical value of χ^2 is equal to 5.991 in terms of the level of statistical significance 0.05. Since $\chi^2_{emp} < \chi^2_{cr}$, the differences between these distributions are not significant. Thus, it is possible to conduct the pedagogical experiment in these groups.

The homogeneity of control and experimental samples was proved based on the results obtained from statistical processing of initial levels of students' professional development and readiness for it (calculating χ^2 (p>0.05)) to compare the distribution of CG and EG students (see Table 2).

Table 2. Levels of future teachers' professional development

| Stages of experiment | Group | Levels | | | | | | χ^2 |
| | | low | | average | | high | | |
		individuals	%	individuals	%	individuals	%	
Ascertaining	EG	110	54.5	72	35.9	19	9.6	0.076
	CG	109	54.3	71	35.8	20	9.9	
Formative	EG	52	25.7	112	55.7	37	18.6	
	CG	103	51.3	76	38.3	21	10.4	68.51

Source: The result of the author's analysis

The obtained results of initial tests and their analysis show that CG and EG students are mostly at low (54.3% in CG and 54.5% in EG) and average levels of future science teachers' professional development (35.8% in CG and 35.9% in EG). Only 9.9% of CG students and 9.6% of EG students are at high levels (Table 2). The difference in the percentage equivalent is greatest in the number of students who received low progress grades.

The analysis of the obtained experimental data makes it possible to study the dependence of future science teachers' professional development on the structural components and identify the degree of impact of each of them (Table 3).

Table 3. The dynamics in levels of future teachers' professional development

Component	Group	Before the experiment							After the experiment						
		low		average		high		χ^2	low		average		high		χ^2
		ind	%	ind	%	ind	%		ind	%	ind	%	ind	%	
Motivational	EG	111	55.4	72	35.7	18	8.9	0.27	49	24.5	118	58.7	34	16.8	79.52
	CG	107	53.5	75	37.5	18	9		103	51.5	77	38.5	20	10	
Cognitive and activity-related	EG	106	52.6	72	35.6	24	11.8	0.10	52	25.9	111	55.2	38	18.9	55.66
	CG	103	51.5	73	36.3	24	12.2		98	48.9	78	38.9	24	12.2	
Reflexive	EG	112	55.6	73	36.2	16	8.2	0.70	54	26.8	107	53.3	40	19.9	73.69
	CG	116	58	67	33.5	17	8.5		107	53.5	75	37.5	18	9	

Source: The result of the author's analysis

Most CG and EG students demonstrate low levels of professional development in all its components: the motivational component − 53.5% and 55.4%; the cognitive and activity-related component − 51.5% and 52.6%; the reflexive component − 58.0% and 55.6%. The experiment proves the statistically significant impact of each component on the general level of professional development and readiness for it.

Certain statistically significant changes ($p<0.05$) in EG compared with CG were detected after the introduction of the pedagogical experiment. It indicates the effectiveness of the applied methodology (Table 2).

A comparative description of results from the distribution of CG and EG students by levels of professional development compared to the ascertaining stage shows some positive changes in EG in contrast to CG (Figure 2).
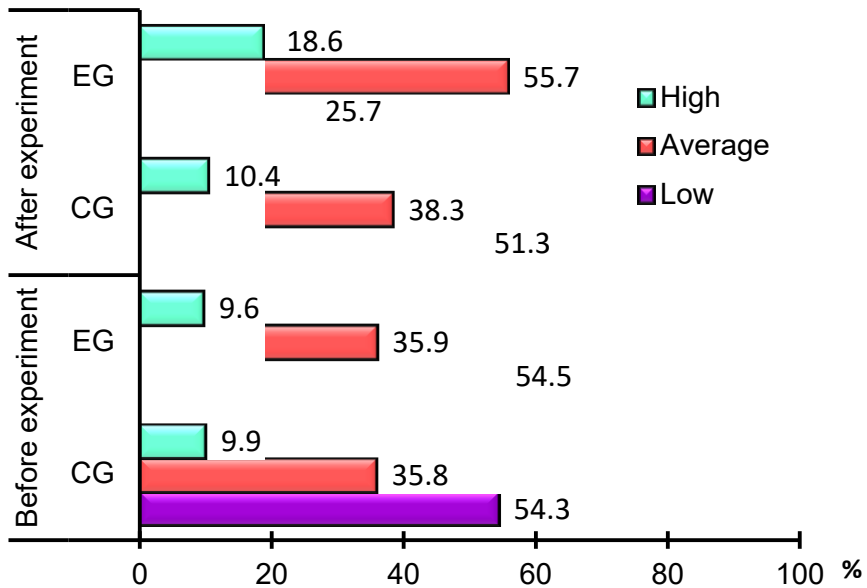
Fig. 2. *The dynamics in levels of future science teachers' professional development*

Source: The result of the author's analysis

According to the motivational component, statistical verification (Pearson's chi-squared test (χ^2)) of the results obtained from the next series of tests shows the lack of correspondence between the levels of CG and EG students. Since $\chi^2_{emp} > \chi^2_{cr}$, the differences between the distribution are significant.

At the end of the experiment, final tests were conducted to determine development levels of each component. According to the motivational and axiological component, the number of students with high and average levels amounted to 75.5% in EG and 48.5% in CG, which is by 30.9% and 2% more, respectively, compared to the results of the ascertaining stage. As for the cognitive and activity-related component, the results were as follows: 74.1% EG and 51.1% CG, which is by 26.7% and 2.6% more, respectively. As evidenced by the reflexive component, this number amounted to 73.2% in EG and 42.0% in CG, which is by 28.8% and 4.5% more, respectively. The slight increase in professional development levels of CG students is explained by the open training system for CG and EG. The final generalization of the obtained data presents positive qualitative results based on some criteria of students' professional development (see Table 1) and as a whole (see Figure

2).

The analysis of the results allows one to compare the distribution of future science teachers by levels of professional development. The generalized results of professional development levels show the following: 51.3% of CG students are at a low level compared to 25.7% of EG students; 38.3% of CG students are at an average level as opposed to 55.7% of EG students; 10.4% of CG students are at a high level in contrast to 18.6% of EG students.

In EG, the number of students with a low level of professional development has decreased by 28.8%. At the same time, the number of students with average and high levels has increased by 19.8% and 9.0%, respectively. In CG, however, these levels have hardly changed.

In CG, one can see much lower indicators than quantitative and qualitative indicators of EG students. It proves the effectiveness of the author's model and the justified pedagogical conditions. The verification of statistical significance of EG and CG results shows that the differences in the distribution of students by future science teachers' professional development levels are statistically significant with a probability of 0.95.

4. Discussion

The results of the experiment confirm the assumption that the traditional system of professional training for future science teachers does not provide the appropriate level of their professional development and readiness for it and may need improving. The developed model of future teachers' professional development can positively affect such a situation.

The study finds that one can enhance the effectiveness of professional development of future science teachers based on the justified theoretical and methodical principles of the study and pedagogical support aimed at reinforcing internal determinants of the individual, which corresponds with today's educational paradigms and social requirements for professional training of future science teachers in higher education institutions.

The scientific value of the obtained results lies in developing, justifying and experimentally verifying the author's model for implementing the system of future science teachers' professional development. It is interpreted in certain specific forms, methods and technologies of teaching and learning. The implementation of the model is a complex, dialectical and dynamic process based on the subject-subject interaction during classroom and independent work in higher education institutions and during placements.

The uniqueness of the proposed model is a comprehensive approach to the professional development of future teachers, which allows one to take into account the dynamics and mechanisms of self-organization of the actors in the educational process. It involves developing multiple metacognitive knowledge and competency-based experience of self-study activities. This model is based on the use of information technologies and the introduction of elements of distance learning, focusing the educational process on independent work and self-study. Finally, it adheres to the pedagogy of partnership and pedagogical facilitation aimed at activating internal determinants of individuals and thus meets modern educational paradigms and social requirements for professional training of future teachers in higher education institutions.

The following aspects have been further developed: methodological, theoretical and methodical principles of future science teachers' professional development; the introduction of innovative technologies and methods into the educational process; the understanding of future science teachers' professional development as a conscious, constant, active, global, purposeful, systematic, independent, proactive, every-day, multifaceted, holistic, individual, dynamic and step-by-step process under the conditions of students' professional training.

5. Conclusions

1. The analysis of scientific-methodical literature, theses, curricula, syllabi and practice of teacher training proves the relevance of the issue of future teachers' professional development.

2. The study determines structural components of future teachers' professional development: self-actualization, self-cognition and self-study, which are interconnected and interdependent since any changes in the content of one of the components lead to changes in others. Readiness for professional development is defined as the result of future science teachers' professional development. The concept of "readiness for professional development" is justified through the concept of "professional development". It allows one to identify the compliance of their structural components.

3. The obtained results of initial tests and their analysis prove that CG and EG students are mostly at low levels of professional development and readiness for it.

4. The study presents the author's model of the system of future teachers' professional development, which contributes to developing structural components of professional development and readiness for it. The

conducted experiment proves the positive impact of this model on the development of motivational, cognitive and activity-related, reflexive components by demonstrating some positive dynamics in the levels of EG students. The number of EG students with low levels of professional development has decreased by 28.8%. The number of EG students with average and high levels has increased by 19.8% and 9.0%, respectively. At the same time, the levels of CG students have hardly changed. The differences in the distribution of students by future science teachers' professional development levels are statistically significant with a probability of 0.95.

5. This study does not disclose all aspects of the issue of future teachers' professional development. Further research should aim to study theoretical and methodical principles of training university teachers to motivate future teachers for professional development.

Conflicts of interest

The authors declare that there is no conflict of interests.

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