Journal of Curriculum Studies Research

https://curriculumstudies.org

E-ISSN: 2690-2788

Volume: 7 Issue: 2 2025

pp. 114-139

Effect of Practice-Oriented Courses in the Study of Natural Sciences on the Development of Professional Qualities in College Students

Nagima Amirgalina[a], Tolkyn Slambekova[b], Karylgash Kazhimova*[c], Gulnara Issayeva[d] & Saltanat Taspayeva[e]

* Corresponding author
Email:KarylgashKazhimova@outlook.com
a. Department of General Education Subjects, SMEEM“ Taldykorgan agro-technical College”, Kazakhstan
b. Faculty of Social Sciences, Department «Pedagogy», L.N. Gumilyov Eurasian National University, Kazakhstan
c. Faculty of Pedagogy, Department of Pedagogy and Psychology, Makhambet Utemisov West Kazakhstan State University, Kazakhstan
d. Abai Kazakh National Pedagogical University, Kazakhstan

Article Info
Received: September 03, 2024
Accepted: May 12, 2025
Published: August 10, 2025

10.46303/jcsr.2025.14

How to cite
Amirgalina, N., Slambekova, T., Kazhimova, K., Issayeva, G. & Taspayeva, S. (2025). Effect of Practice-Oriented Courses in the Study of Natural Sciences on the Development of Professional Qualities in College Students. *Journal of Curriculum Studies Research*, 7(2), 114-139.
https://doi.org/10.46303/jcsr.2025.14

ABSTRACT
The purpose of this study is to identify the professional qualities required of students specializing in "Vocational Training A training experiment method was employed as the primary method, conducted at the pedagogical and agrotechnical colleges of Taldykorgan, Kazakhstan. The experiment involved 128 students, randomly divided into two groups (experimental and control). N.V. Noss' occupational questionnaire was employed to assess the progress of the experiment. The results were analyzed using statistical methods, calculating individual and average group test performance coefficients. The study findings revealed that students in the control group exhibited poorly developed professional qualities, while the experimental group showed considerable improvement. Students in the experimental group showed better theoretical knowledge, practical skills, and soft skills such as independent decision-making and proficiency with computers and office equipment. Based on the results of the pedagogical experiment, the authors propose pedagogical conditions and a specialist training model aimed at fostering students' interest in natural sciences and enhancing their professional qualities.

KEYWORDS
Vocational training; educational standard; competency; graduate model; professional competencies; specialist.

INTRODUCTION

The pivotal task of education is to equip young people with the knowledge, abilities, and skills needed to prepare them for employment, self-employment, business, and entrepreneurship (Kostromina et al., 2023; Tikhomirova et al., 2022; Turgumbayeva et al., 2023). This approach not only provides them with a profession but also ensures social protection (Sikandar et al., 2022; Sithole & Dube 2025). In Kazakhstan, vocational education is gaining increasing popularity among youth due to its accessibility and practicality (Matabane et al., 2022; Nikisi et al., 2025; Smagulov et al., 2023; Togaibayeva et al., 2023). To meet the current and prospective needs of the national economy for skilled professionals, vocational education must focus on aligning with these needs (Uteuliyev et al., 2023; Vlasov & Iamshchikova, 1998). Strengthening high-demand and promising training areas is essential, as is refining secondary vocational education curricula to emphasize practical skills and provide practical qualifications (Abdullayev et al., 2024; Nurgalieva & Kudysheva, 1994).

One of the fundamental goals of education is to broaden individuals' perspectives, foster interdisciplinary thinking, improve their ability to make independent creative decisions, and cultivate self-learning skills and humanistic values (Akhmetshin et al., 2024; Bylieva et al., 2023; Gimranova et al., 2023). Developing professional qualities requires shifting the focus of education toward its upbringing and developmental functions, emphasizing the holistic growth of future specialists. This includes nurturing their personality, ensuring harmonious spiritual and moral development, and fostering high psychological stability and readiness for productive work (Iskakov et al., 2023). In this context, cultivating a culture of professional activity in future specialists is essential. Professional qualities, a vital aspect of human resources, are a prerequisite for professional work (Abdiyev et al., 2025; Boronenko & Fedotova, 2023; Kurniawan et al., 2023). These qualities naturally evolve and improve with practice, ultimately transforming the quality of work itself. They can manifest as mental processes, states, motives, and attitudes toward work and interpersonal relationships (Adolf, 1998; Akhmetova & Strizhova, 2005; Alimov, 2014). The importance of specific professional characteristics varies across a continuum from incompetence to mastery, with some attributes gaining importance up to a certain level, after which they become irrelevant to professional competence (Babanskii, 1982; Belkina et al., 2006).

Table 1.

Characteristics of Professional Qualities

No.	Characteristics of professional qualities	Essence of professional qualities
1.	Labor efficiency by key characteristics	Performance, reliability
2.	Mental characteristics	Thinking, sensory, speech, mnemic
3.	Communication characteristics	Communication, relationships

Source: Compiled by the authors.

Now, let us examine the professional qualities of college graduates as proposed by contemporary researchers. Various authors, including Belkina et al. (2006), Derkach & Orban

(1995), Derkach & Kuzmina (1993), Lebedev et al. (2003), Mukhorina (2009), Bronevshchuk (2004), and Krylova (1990), have suggested frameworks outlining the structure of professional qualities for college students. These proposed structures are summarized in Table 1.

Several Kazakh studies highlight the essence of a specialist's model, emphasizing key qualifications, professional qualifications, and core competencies (Iskindirova et al., 2024; Sarsenbayeva et al., 2024; Sekerbayeva et al., 2023). We claim that such a model should integrate the relationships between general, professional, and personal training. In this study, to construct a professional model of a graduate specialist, we propose the following quality requirements for training: General (key) qualities (Mavrodina & Kurganskaya, 2023);

- Professional (basic) qualities (Ling et al., 2023);
- Qualities of personal development (Archugova et al., 2023).

Building on these arguments, we propose a model structured around competencies developed through natural science, general, specialized, humanities, and socio-economic disciplines. The basic competencies are those cultivated through the study of mathematics, natural science, and general disciplines, including the ability to analyze and synthesize information, and foundational skills in reading, drafting, and formatting text and graphic documentation, among others (Decree of the President of the Republic of Kazakhstan, 2008).

The model should reflect the structure of the student's professional work, shaped by their position and job functions. Hence, it should serve as a reference in education that reduces technocratic dominance, even within the model itself. It must prioritize the development of the student's professional and personal qualities while excluding the standardization of personality or manipulation of the student's mindset. Furthermore, the model should be realistic, ensuring its application closely approximates the specialist's future professional practice.

The alignment of the college graduate model with the real conditions of professional work is a critical factor in selecting appropriate technological means to train competent specialists (Abdiyev et al., 2023; Bobkov et al., 2022; Kazahbaeva, 2010; Klarin, 1989). As optimizing learning needs fulfilling the function of dynamic transformation, the model should also exhibit dynamic characteristics (Levina, 2001; Litvinova, 2006). These dynamics involve stages of the learning process, where material is periodically revisited at higher levels of training (Isaev & Akchurin, 2004; Isaeva, 2006; Noss & Noss, 2002; Nurgalieva & Kudysheva, 1994). This iterative approach ensures that changes in society are continuously integrated into the learning process, thereby aligning graduates' competencies with evolving market demands. Such adaptability strengthens the competitiveness of graduates in the labor market (Gusev et al., 2002; Vvedenskii, 2003; Order of the Minister of Education and Science of the Republic of Kazakhstan, 2009).

The model enables preliminary forecasting of possible professional actions, which is a critical characteristic for optimizing the training process. In this context, forecasting involves looking ahead to anticipate both short- and long-term prospects in specialist training. This forecast should not only address developments in production technology but also monitor the

development of future specialists, taking into account their abilities and the internal and external factors affecting competency development (Gadzaova et al., 2023). This foresight helps align students with their future professional activities, providing a clear orientation toward their career paths. Thus, the model provides an adequate and dynamic understanding of the real conditions of future professional work (Prokudina et al., 2022).

The development of basic competencies based on natural science and general disciplines depends on students' initial competencies (Dyantyi et al., 2024). These are not limited to knowledge and skills in subjects like algebra, geometry, physics, chemistry, and biology. The development of basic personal professional competencies, including communication and social-personal qualities, also requires a "starting capital," developed prior to college (Stytsyuk et al., 2022). Competencies are cultivated—and sometimes formed – directly during the training process. This process should occur within the interaction of natural science and humanities disciplines, showing the practical relevance of specific subjects. Creating scenarios resembling industrial settings can help students understand the necessity of studying certain subjects. Moreover, students should be shown how other disciplines beyond the subject at hand may be required to resolve specific challenges. Accordingly, natural science subjects should be presented with an emphasis on their connection to qualification disciplines within this competency group.

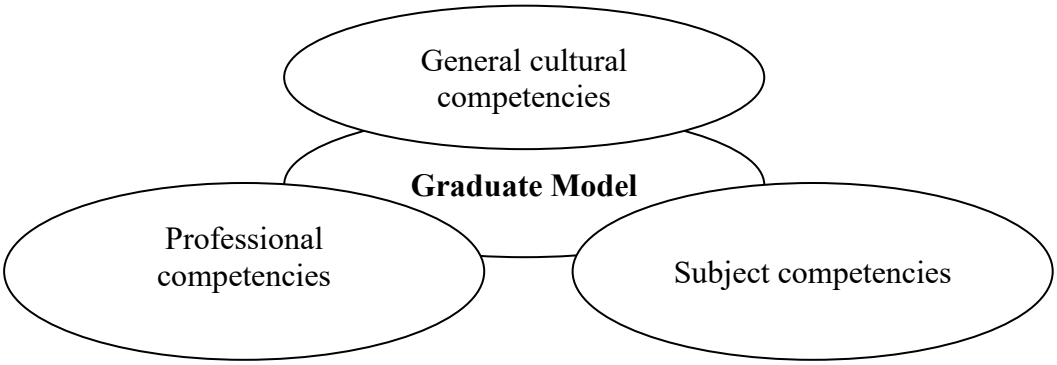
For example, in economic and technical colleges, practical classes in subjects like chemistry, biology, physics, and ecology (Ybyraimzhanov et al., 2023) employ role-playing and live dialogue, such as discussions of students' results, rather than relying solely on formal reiteration of material from reports and lectures (Malika et al., 2022). The interrelation of natural sciences is evident; for instance, a physics teacher cannot effectively teach the entire physics course without employing mathematical formulas or drawing upon knowledge of nature.

This leads to the conclusion that mastering a competence requires more than knowledge of a single subject or part of it; disciplines need to be studied in conjunction (Terekhova, 2019). These interrelations are essential for developing competencies, as the desired outcomes cannot be achieved without them. The absence of one link within this interconnected framework decreases the specialist's overall professional competence (Kapustina & Goyushova, 2024; Stavruk et al., 2023). Therefore, to produce a competent graduate, the educational process must be optimized to align with professional qualifications and personal professional competencies, utilizing the most effective training technologies. Accordingly, we introduce a model of a college graduate encompassing three types of competencies (Figure 1).

Based on this, we identified the competencies required of a college graduate. Professional qualities are derived from the characteristics of the graduate's personality. Table 2 outlines the general (key), professional (basic), and personal development characteristics derived from the model, along with their definitions and interpretations.

Figure 1.

Model of a graduate



(Source: compiled by the authors)

Table 2.

Professional qualities in the model of a college graduate specialist

No.	Quality	Professional qualities
1.	*General (key) qualities*	Mastery of theoretical knowledge
		Proficiency with computers and office equipment
		Employability and high labor discipline
		Knowledge of foreign languages
		High mobility
2.	*Professional (basic) qualities*	Mastery of practical skills
		Ability to independent decision-making
3.	*Qualities of personal development*	Communication skills (knowledge of communication psychology, stress resistance)
		Organizational skills
		Positive thinking, initiative

Source: Compiled by the authors.

The key prerequisites for developing the professional qualities of college students are their personal abilities, which include the following:

- *Need for professional work:* This refers to a person's readiness to act based on their needs. Beyond the need to work, individuals may also seek to secure their livelihood, find meaning in life, accomplish goals, achieve self-actualization, engage in creative activities, join social circles, gain recognition, ensure safety, and attain satisfaction.
- *Professional aptitude* (natural gifts): This involves natural talents and abilities that affect individuals to excel in certain professional skills.

- *Value orientations:* These are socially recognized frameworks for evaluating the purpose of labor, encompassing a system of spiritual values, professional mentalities, and professional ethics.

By analyzing prior pedagogical research, we compiled a matrix of pedagogical conditions aimed at improving students' professional qualities. This matrix seeks to capture the approaches of both teachers and college students toward professional activities (Table 3, see appendix).

Studies conducted at colleges reported that stronger and weaker students differ not in intellectual parameters but in the level of development of professional qualities (Monoszon, 1992; Rean, 1990). Thus, fostering an interest in the profession emerges as an important condition for the motivational component of students' professional development. An important aspect of our research was to examine the development of professional qualities through the study of natural sciences (Morudu, 2025). These disciplines possess considerable potential to guide students toward various professional fields, such as agriculture, medicine, ecology, the medical and biological industries, biological cybernetics, and biophysics (Abdullayev et al., 2023). One of the objectives of this study is to provide substantiation for a model that facilitates the development of students' professional qualities through the study of natural sciences in college settings (Figure 2, see appendix).

In pedagogical science, the modeling method has been substantiated by scientific researchers (Boldyrev & Bitinas, 1996; Monoszon, 1992; Nauryzbai, 1997; Nurgalieva & Kudysheva, 1994; Skatkin, 1980). Natural sciences, taught at colleges across all specializations, perform the functions described in the pedagogical model for developing students' professional qualities. These disciplines provide foundational knowledge in chemistry, biology, and environmental science, fostering qualities essential for occupations with agronomic, chemical, biological, and ecological orientations. Such professions include ecologist, cytologist, biochemist, medical and biological physics or cybernetics engineer, agronomist, and veterinarian, among others.

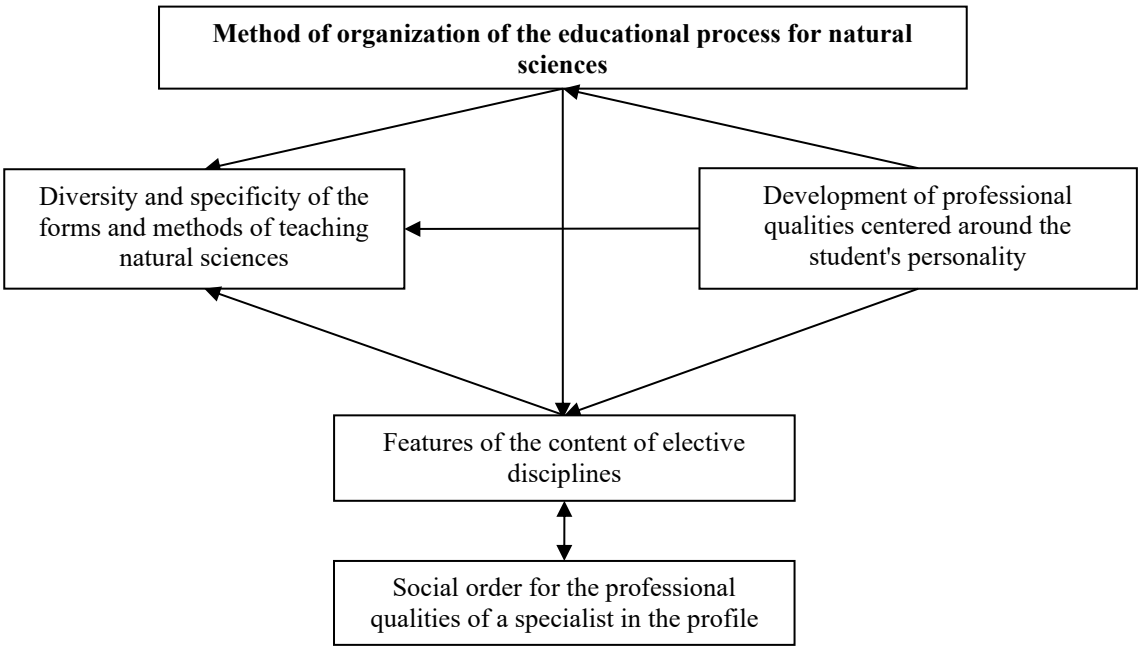
The factors that affect the efficiency of the application of professional qualities include:

- Social order for the professional qualities of a specialist,
- Development of professional qualities centered around the student's personality,
- The diversity and specifics of the forms and methods of teaching natural sciences,
- Features of the content of elective disciplines (Figure 3).
- The knowledge and skills acquired during the learning process show the practical application of natural sciences, develop interest in the subjects, and motivate students to seek deeper knowledge. A particularly noteworthy result of developing professional qualities through the study of natural sciences is the cultivation of a positive attitude toward labor among students (Hudayberganov et al., 2025).

Psychological and pedagogical support for students' professional qualities can be established as a key pedagogical condition. As argued by some authors (Aubakirova et al., 2025; Bespalko, 1997; Podymov & Podymova, 1996), the provision of psychological services in colleges is essential to meet new demands for training highly qualified specialists. Such psychological and pedagogical support represents an integral process that involves studying, forming, developing, and adjusting the professional personality of future specialists.

Figure 3.

Relationships between factors affecting the development of professional qualities as part of studying natural sciences



Source: Compiled by the authors.

The methods for developing professional qualities during the study of natural sciences can be categorized into the following groups:

1. Methods to develop interest in natural sciences as a field of practical work,
2. Methods to teach about the professions associated with natural sciences,
3. Methods to teach basic professional skills.

The objective of this study is to assess how practice-oriented courses in natural sciences contribute to developing key professional qualities in vocational students. To achieve this, the following direct and indirect research questions were formulated:

Direct Research Questions:

1. How do practice-oriented courses influence students' achievement in natural sciences?
2. What is the impact of practice-oriented courses on the development of students' professional qualities?

Indirect Research Questions:

3. How does achievement in natural sciences correlate with the development of professional qualities?
4. What is the combined effect of natural sciences achievement and professional qualities on students' participation in practice-oriented courses?

The research hypothesis was tested using descriptive statistics and Chi-square (χ^2) analysis, assessing differences in mastery of theoretical knowledge, practical skills, and independent decision-making. Statistical tests compared the initial and final results of students' professional development across the two groups.

METHODS

Study Design

To evaluate the efficiency of the developed method for professional training through the study of natural sciences, the study employed a learning experiment method. The formative experiment, designed to focus on the development of students' personalities, was tested in various training settings: in groups with a natural science profile and among students in the basic program. A key condition of the experimental training was the extensive integration of professional training content into the teaching of natural sciences. Another critical aspect was ensuring a close relationship between this content and the educational material in the curriculum, maintaining maximum accessibility. These conditions adhered to the principles of scientific credibility, educational accessibility, and alignment with professional training.

Students in the experimental groups participated in several lessons designed to support their professional development. In the first introductory lessons in biology, chemistry, and environmental science, emphasis was placed on the importance of professional self-determination in future practice. These lessons highlighted the value of correlating knowledge about professions with individual personal qualities to make informed career choices. Students were also informed about the importance of natural science knowledge not only for training specialists in environmental, agricultural, technological, and related fields but also for everyday life applications. Subsequent lessons focused on scientific achievements, future prospects, and practical applications of natural science knowledge in various fields. These topics aimed to develop interest in the subjects while reinforcing students' motivation throughout the experimental training. Stable motivation was further supported by sharing inspiring stories about the professional development of prominent figures in science and practice, as well as tangible personal achievements stemming from education. An individual approach to each student’s choice of a profession related to natural sciences was a key condition of the implemented professional training method. This personalized approach included professional consultations as a content component of the experimental training helping students align their interests and abilities with potential career paths.

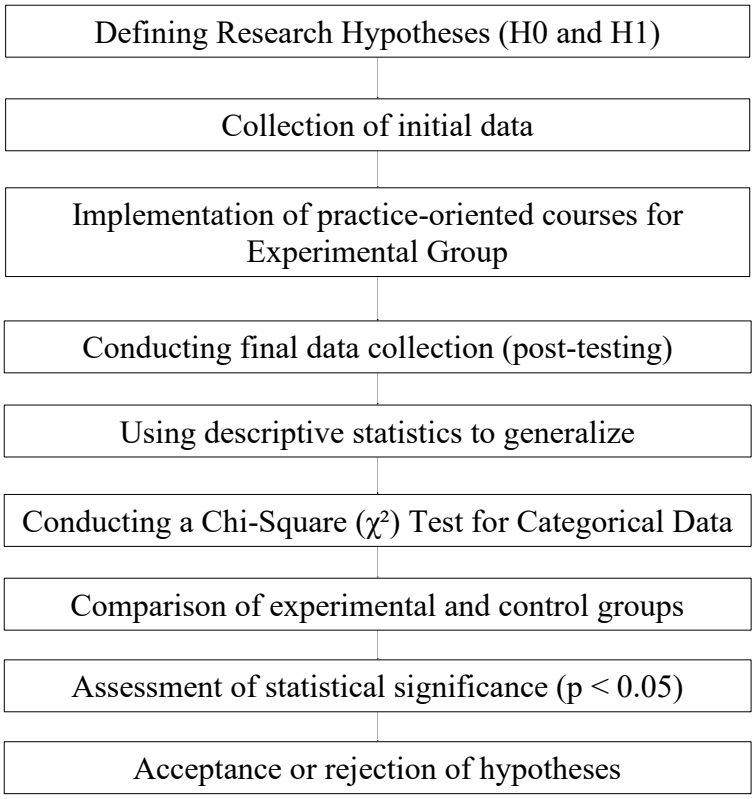
Null Hypothesis (H_o): There is no significant difference in the distribution of professional qualities between the two groups.

Alternative Hypothesis (H_1): The practice-oriented courses significantly improve students' professional qualities compared to the traditional curriculum.

The following figure outlines the key steps in the hypothesis testing approach used in this study (Figure 4).

Figure 4.

Procedure for Hypothesis Testing in the Study



Study Sample

The experimental group consisted of 128 students from pedagogical and agro-technical colleges in Taldykorgan, Kazakhstan. Students were randomly assigned into two equal groups of 64 each. This randomized allocation was crucial for ensuring the comparability of the groups and the validity of the findings. Maintaining equal group sizes minimized bias and increased the statistical power of the analysis, enabling a more accurate evaluation of the intervention's effectiveness.

Instrument and instrument validation

The study utilized a consultation-based instrument, with conceptual tools tailored to the specific objectives of the consultations:

1. Professionally important personal qualities and professional aptitudes were assessed through psychological methods.
2. Management of the process of learning about various professions was ensured using special tasks completed by students.

3. Stimulation of professional self-development of the necessary professional features was achieved in individual conversations.

This approach implements the principles of individualization, aligning with students' individual characteristics and the requirements of their chosen profession, fostering specialization in the study of natural sciences. The structure and content of the method were designed to ensure the continuous successive, and phased integration of professional material into the teaching of biology at the college level. The experimental method consisted of three stages. In addition to preliminary consultations, the methods employed in the pedagogical experiment included surveys, testing, interviews, and observation. Changes in the level of professional qualities were assessed using the occupational questionnaire developed by Noss (2002), which categorized qualities into 10 thematic groups, each containing a specific set of attributes. To evaluate the test assignments administered at the beginning and end of the experiment, a summary description of the modern training tool was compiled. This summary incorporated structural elements proposed by students and those added by the teacher. A panel of college teachers served as experts to determine the weight of these task groups, ensuring the evaluation's validity and alignment with professional standards.

Data collection

The experimental method consisted of three stages:

1. Preparatory Stage:

The teacher motivated students to engage successfully with the study of natural sciences and professional training, creating a foundation for further learning.

2. Main Stage:

This stage focused on the learning and vocational training process. Based on the content of each class, the teacher provided students with information about various professions or specialties, including their significance, required knowledge (e.g., biology), content and conditions of work, professional operations, and necessary skills. This information also included details about personnel training systems, aiming to stimulate students' interest in biology. Additionally, students conducted independent research into professions, which involved:

- Compiling a professiogram,
- Developing practical and basic professional skills,
- Conducting an in-depth study of applied issues related to the profession.

3. Final Stage:

The focus was on fostering students' conscious intention to work in their chosen profession upon completing their education, ensuring a clear alignment between their training and career aspirations.

In the first year, an ascertaining experiment was conducted at the Bilim Humanitarian Technical College and the Taldykorgan Agro-Technical College to test the research hypothesis, make adjustments to the process of developing professional qualities, and identify the

necessary pedagogical conditions for professional training within the context of teaching natural sciences.

Data analysis

The results from the ascertaining and control stages of the experiment were analyzed using statistical methods. Individual and average group test performance coefficients were calculated separately for the control and experimental groups, following the methodology outlined by Vershilovskii and Lesokhina (1982).

The individual test performance coefficient K_i was determined using formula,

$$K_i = \frac{\sum_{i-1}^{N} N_i}{N_{max}} \quad (1)$$

where N_i is the test score of the i-th student and N_{max} is the maximum test score (N_{max}=19).

The average coefficient of test performance K_{av} was calculated using formula

$$K_{av} = \frac{\sum_{i-1}^{N} K_i}{n} \quad (2)$$

where K_i is individual test performance coefficients and n is the number of students taking the test.

Next, the results of the two groups, before and after the experiment, were compared using statistical methods. Student's t-test was used to evaluate the differences in test performance coefficients, assessing whether the observed changes were statistically significant. Additionally, a chi-square test was utilized to analyze the distributions of professional qualities categorized as "Low," "Average," and "High" across the control and experimental groups. This test evaluates whether there are statistically significant differences in the proportions of students within these categories between the two groups. To assess the impact of the practice-oriented intervention, the study used descriptive statistics and Chi-square (χ^2) analysis to test hypotheses regarding differences in students' professional qualities. A significance level of $p < 0.05$ was set for hypothesis testing. The chi-square test is a widely utilized method in social science research for comparing categorical data between groups. It is particularly effective for analyzing relationships or differences in variables such as gender, preferences, or survey responses. Its efficiency lies in handling non-parametric data and evaluating associations without requiring strict assumptions about data distribution (Aboimova et al., 2024).

RESULTS

Before the experiment, the results showed no statistically significant difference between the two groups in their prioritization of professional qualities at the ascertaining stage ($p > 0.05$). This finding confirms the equivalence of the groups prior to the intervention, providing a robust foundation for further analysis in the formative experiment. The study found that first-year

students placed the least priority on organizational skills, positive thinking, initiative, and practical skills. This can be attributed to their limited involvement in social work activities at the college and the fact that their curriculum primarily covers general education disciplines. Conversely, first-year students prioritized mastery of theoretical knowledge and proficiency with computers and office equipment. This likely reflects their recent focus on basic school subjects, where theoretical knowledge was emphasized. Across all years of study, the greatest share of students prioritized theoretical knowledge and proficiency with computers and office equipment. However, differences emerged in the specific qualities chosen within each thematic block. Common qualities identified by students across all years include employability, high labor discipline, high mobility, mastery of practical skills, and medium-level proficiency in foreign languages. Third-year students, however, emphasized additional qualities not prioritized by younger students, such as independent decision-making, communication skills (e.g., knowledge of communication psychology and stress resistance), organizational skills, positive thinking, and initiative.

Table 4 provides the survey results.

Table 4.

Comparative analysis of the priority of professionally important qualities among students %

Professional quality	**Priority of professional quality**		
	1st year	**2nd year**	**3rd year**
Mastery of theoretical knowledge	23.2	29.8	47
Proficiency with computers and office equipment	19.6	34.2	46.2
Employability and high labor discipline	15	38.2	46.8
Medium-level proficiency in foreign languages	14	45.5	40.5
High mobility	12	42.2	45.8
Mastery of practical skills	10.2	26.1	63.7
Ability to independent decision-making	12.2	24	63.8
Communication skills (knowledge of communication psychology, stress resistance)	11.1	21.1	67.8
Organizational skills	9.6	26.8	63.6
Positive thinking, initiative	11	33.7	55.3

Source: Compiled by the authors

As a result, we identified a set of the most important qualities noted by students across all years of study: business, intellectual, and psychological qualities. However, differences were observed in the specific content of these qualities as indicated by third-year students. This suggests that, over the course of their training, students develop a deeper understanding and recognition of professionally important qualities, facilitated by targeted activities within the educational process. The testing results provide valuable insights into the knowledge, practical skills, and reasoning abilities of students (Table 5).

Table 5.

Results of the ascertaining experiment

Professional quality	Professional quality indicator, %					
	Control group			Experimental group		
	low	Average	high	low	average	high
Mastery of theoretical knowledge	45.1	50.0	4.9	47.0	48.8	4.2
Mastery of practical skills	36.0	54.1	9.9	35.2	54.9	9.9
Ability to independent decision-making	65.1	30.9	4.0	58.0	38.8	3.2
Proficiency with computers and office equipment	76.0	22.9	1.1	71.0	26.8	2.2

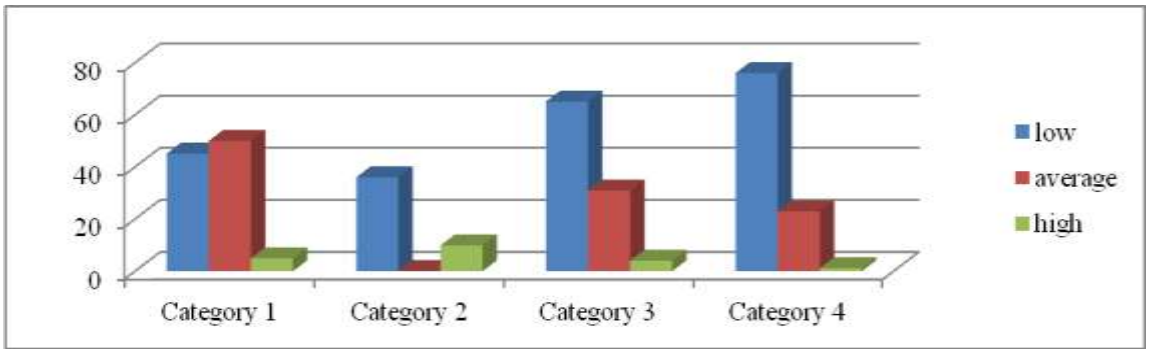
Source: Compiled by the authors.

The test revealed a statistically significant difference between the groups at the ascertaining stage ($\chi^2 = 8.521$, $p < 0.01$). This difference shows that, even before the intervention, the experimental group exhibited a more favorable distribution of professional qualities compared to the control group. This finding highlights the need to implement pedagogical models to further enhance these qualities and address disparities effectively in vocational training programs. The students' professional qualities align with the criteria of knowledge, abilities, and skills, as assessed through testing.

Figure 5.

Indicators of the control group at the start of the pedagogical experiment

Source: compiled by the authors.

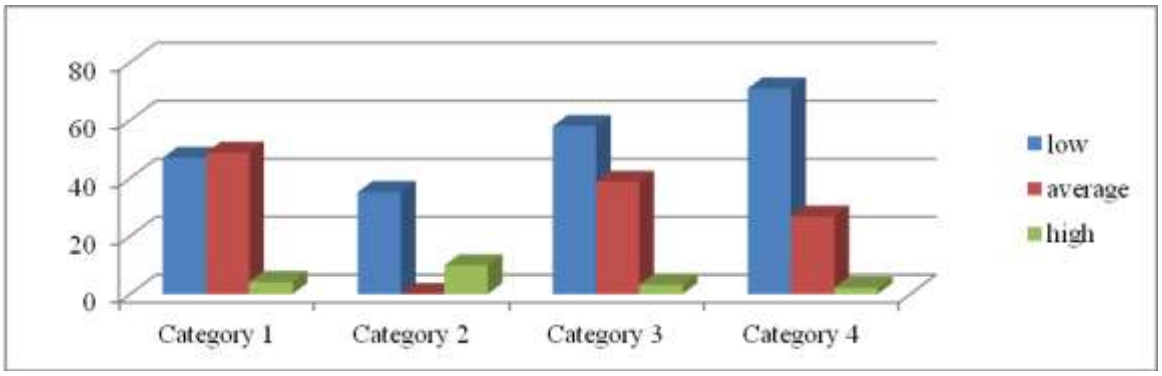


Figures 5 and 6 illustrate that both the control and experimental groups had virtually identical levels of professional qualities at the start of the experiment, ensuring a comparable baseline for evaluating the impact of the intervention.

Figure 6.

Indicators of the experimental group at the start of the pedagogical experiment

Source: compiled by the authors.



After conducting training aimed at developing the professional qualities of college students, along with the previously mentioned forms of assessment of their knowledge, abilities, and skills, tests were administered to both groups. The subsequent stages of the pedagogical experiment focused on providing pedagogical guidance to support the formation of an educational system for the vocational training of college students (Table 6).

Table 6.

Results of the formative experiment

Professional quality	Professional quality indicator, %					
	Control group			Experimental group		
	Low	Average	High	Low	Average	High
Mastery of theoretical knowledge	49.0	44.2	6.8	7.1	67.9	25.0
Mastery of practical skills	24.1	63.9	12.0	3.0	72.8	23.2
Ability to independent decision-making	46.0	47.0	7.0	13.0	64.8	22.2

Proficiency with computers and office equipment	58.1	38.0	3.9	4.0	77.8	21.2

Source: Compiled by the authors

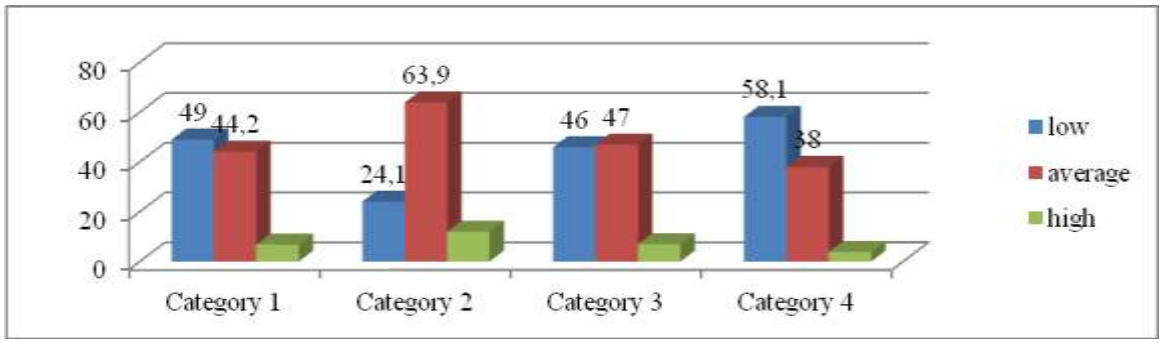
Table 6 shows a significant improvement in professional qualities within the experimental group after implementing the pedagogical model. A chi-square test revealed a statistically significant difference in the distributions of professional quality indicators between the control and experimental groups ($\chi^2 = 23.472$, $p < 0.001$). The experimental group showed notably higher proportions of students in the "High" category across all professional qualities, including mastery of theoretical knowledge (25.0% vs. 6.8%), mastery of practical skills (23.2% vs. 12.0%), ability to make independent decisions (22.2% vs. 7.0%), and proficiency with computers and office equipment (21.2% vs. 3.9%). In contrast, the control group had a predominance of students in the "Low" category across these qualities. These findings confirm the effectiveness of the proposed pedagogical model in enhancing students' professional qualities, underscoring the importance of applied, practice-oriented education in vocational training programs.

The indicators of knowledge, abilities, and skills associated with the proposed professional qualities demonstrate that the pedagogical conditions and professional qualities incorporated into the pedagogical model for developing professional qualities in college students were more effective when implemented in the experimental group. Figures 7 and 8 illustrate that the educational process applied in the experimental group yielded significantly better outcomes compared to the control group, confirming the efficiency of the model.

Figure 7.

Indicators of the control group at the end of the pedagogical experiment

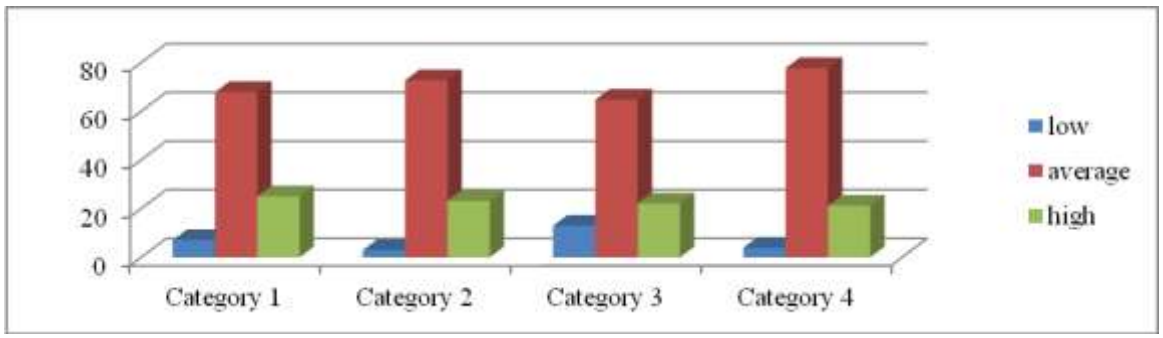
Source: compiled by the authors.



Figures 7 and 8 illustrate that the experimental group has a higher proportion of students with professional qualities at high and average levels compared to the control group. These figures illustrate a significant difference in the development of professional qualities between the two groups. This difference is attributed to the implementation of targeted programs and methods designed to develop professional qualities in the experimental group, alongside the introduction of applied courses that reinforced these qualities.

Figure 8.

Indicators of the experimental group at the end of the pedagogical experiment
Source: compiled by the authors.



DISCUSSION

The study shows a significant improvement in the professional qualities of students in the experimental group, who participated in practice-oriented courses. Since 2018, the experimental group has been part of programs focused on developing professional competence. Students included in the ascertaining experiment engaged in applied courses within these programs. In contrast, the proposed training system was not implemented in the control group, resulting in a lower prevalence of high and average levels of professional qualities and a higher prevalence of low levels. These results show the insufficient development of professional qualities in the control group, emphasizing the effectiveness of the applied approach in the experimental group.

These findings align with study by Mukhasheva (2023) and Yasa (2024), who found that integrating applied exercises and tasks into the curriculum helps students develop critical skills, such as problem-solving, that are vital for addressing real-world challenges in areas like energy, health, and the environment. Similarly, Schultheiss et al. (2023) emphasized that aligning education with industry demands is a critical aspect of applied education, preparing graduates for the labor market. Our study supports these conclusions by showing that applied courses in natural sciences significantly improve students' professional qualities, better equipping them to tackle real-world challenges (Guslyakova et al., 2025).Additionally, the pedagogical model developed in this study builds on the principles of dynamic and integrated learning, consistent with Kapustina and Goyushova's (2024) argument that multidisciplinary training is essential for developing professional competencies. By combining natural sciences with humanities and socio-economic disciplines, the model promotes not only technical skills but also essential qualities such as communication, organizational abilities, and stress resilience. Despite these positive findings, challenges persist. While the experimental group outperformed the control group, certain professional qualities, such as communication and high labor discipline, require further emphasis and refinement in training programs. These gaps align with the observations of Xin and Corpuz (2024), who note that inadequacies in curriculum design and

teaching methods often hinder the development of these qualities. Teachers may struggle to engage students effectively or instill essential labor values, complicating the cultivation of communication skills and discipline in labor contexts. Overall, this study underscores the transformative potential of practice-oriented courses and pedagogical innovations in vocational education. The developed model and its successful implementation offer a valuable framework for further research and practical application in similar educational contexts.

CONCLUSIONS

The conducted analysis of scientific and pedagogical literature led to several conclusions regarding the effective development of professional qualities in colleges, emphasizing the need for meticulous organization and innovative approaches in training, particularly within natural sciences:

1. Through the analysis of pedagogical literature, the concept of professional qualities was clarified, and a definition was proposed. Professional qualities are understood as the individual traits of a person are necessary and sufficient to perform a given activity at the prescribed level of quality.

2. An integrated approach was developed for fostering college students' professional qualities in natural sciences. This includes creating an integrated curriculum, developing a logical structure and systematic planning of the training process, implementing level differentiation in professional tasks to address varying student abilities, providing colleges with up-to-date equipment for practical, hands-on learning, and promoting multidisciplinary competencies to prepare students for dynamic career paths.

3. The proposed pedagogical model addresses the goals of vocational education, defines students' professional qualities, specifies the pedagogical conditions for their development, structures the content and training process, and categorizes levels of students' professional qualities. This model ensures effective training of students as active subjects in their vocational education.

4. The analysis showed insufficient professional potential in the content of natural sciences, prompting the development of a pedagogical model that integrates all content components and methods into professional training. Specialized courses developed and tested within this framework enable the effective cultivation of professional qualities in future specialists.

5. The experiment showed that targeted development of professional qualities, aligned with academic content and methods, improves students' interest in natural sciences, improves professional qualities, fosters conscious professional intentions, and cultivates a positive attitude toward work. Additionally, it facilitates more effective knowledge acquisition and professional readiness.

Thus, the answers to the research questions were obtained. It was found that the key professional qualities required for students in vocational training programs include the ability to assess the current labor market status quo, adapt to market conditions, and develop practice-

oriented soft skills. Practice-oriented courses contribute significantly to improving students' awareness of the practical application of their training. Specially organized consultations, conducted for the experimental group, further reinforced this awareness. The results of the experiment showed that the reorganized pedagogical model effectively equips students with the professional qualities and skills discussed in the study.

The present study primarily focused on designing expected results and defining and classifying pedagogical conditions for the effective development of professional qualities in the study of natural sciences. The data and findings obtained may support further targeted and in-depth pedagogical research into the systemic development of basic, key, and subject-specific qualities through the study of specific natural sciences. Additionally, these findings can inform studies monitoring the value-motivational, cognitive, and emotional-volitional development of students, contributing to a more comprehensive understanding of their professional growth.

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APPENDIX

Table 3.

Pedagogical conditions for the improvement of college students' professional qualities as suggested by researchers

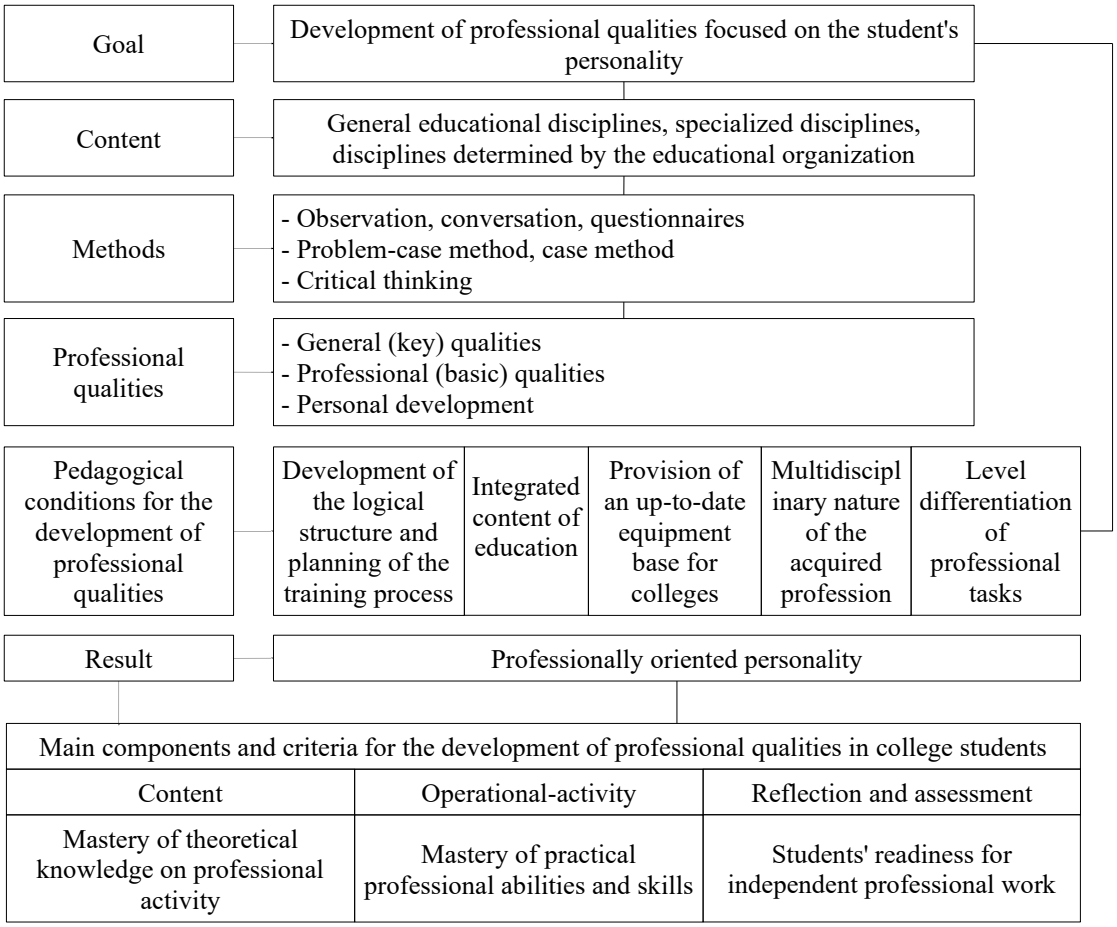
Type of pedagogical conditions	Pedagogical conditions for the development of students' professional qualities	Work of the teacher	Work of the student
Internal	Professional aspirations of the individual	-	Development of interest in the profession
	Abilities of the individual	-	Physical characteristics of the student
	The individual's demands to the conditions of professionalization	-	Requirements for the student's psychological characteristics
External	Socio-economic conditions	Need for professional staff	Recognition of the need for professional training in the current socio-economic conditions
	Leading professional training activities	Preparedness of the teacher for professional teaching activities	-
	Technical and technological level of activity	Creation of the material and technical base of training	Learning in the existing socio-economic conditions
	System of stimulating professional growth	Mastery of the methodology of student training and upbringing	The learning process
	Random circumstances and important life events	Ability to show the positive aspects of random circumstances	Ability to recognize the effect of random circumstances

	Features of the education and upbringing process conducive to the development of students' professional motivation	Competent organization of the educational process at the college	Fulfilling the requirements and policies of the teacher

(Source: compiled by the authors)

Figure 2.

Pedagogical model of the development of students' professional qualities in the study of natural sciences at college



Source: Compiled by the authors