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INITIAL TRAINING METHODOLOGY OF THE PROFESSIONAL COMPETENCES OF THE CHEMISTRY STUDENT IN AN INTERDISCIPLINARY CONTEXT

532.02 SCHOOL DIDACTICS
(Chemistry)

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CONTENT

CONCEPTUAL BENCHMARKS OF THE STUDY

Research relevance. In the context of European education, the training of the competent specialist is one of the objectives that targets the quality of education, so higher education must adjust its documents concerning educational policy to train competent specialists in various fields. With reference to the Education Code of the Republic of Moldova, art. 75 [1], the mission of higher education is to: a) create, preserve and disseminate knowledge at the highest level of excellence; b) training of highly qualified specialists, competitive on the national and international labor market. The integrated approach to the curriculum is thus an alternative, a complementary approach, which can contribute much more effectively in the direction of shaping the learning outcomes required by contemporary society. For the active involvement of the person in the socio-economic activity, the essential purpose of contemporary education is the formation of a unitary character and *the development of a set of competencies, which includes knowledge, competences, attitudes and values* [ibidem]. In this context, the methodology of training the initial professional competence of the chemistry student, in order to demonstrate its efficiency, must focus on the interdisciplinary correlation of the courses contents like chemistry, biology, physics, etc.

Description of the situation in the research field and identification of the research problem: theoretical approaches to the concept of competence and the concept of professional competence are reflected in the research papers of scientists R. White [2]; F. Weinert [5]; И. А. Зимняя [6]; Ph. Jonnaert ș. a. [7]; X. Roegiers [8]; Ph. Perrenoud [49]; Vl. Pâslaru [50]; S. Marcus [11]; L. Paquay [51]; Э. Ф. Зеер [14]; Л. Н. Журбенко [15]; Vl. Guţu, , E. Muraru, O. Dandara, [17]; Ig. Racu [18]; I. Botgros, L. Franţuzan [52]; N. Silistraru, S. Golubițchi [20], R. Dumbrăveanu, etc. [53]; V. Botnari [54] and in documents concerning educational policy: the Education Code of the Republic of Moldova [1], the Reference Framework for National Curriculum [9], the Qualifications Framework for Higher Education [55]. Integrated training has been studied by researchers L. Ciolan [56]; T. Callo [57]; A. Popovici Borzea [58]; O. Bursuc [59]; D. Cozma, A. Pui [60]; N. Bârnaz [61]; L. Ciascai [62]; T. Bejenari etc. [63], however, there wasn't still a correlation of chemistry contents with biology, physics, informatics in an interdisciplinary context.

Reckoning the theoretical and applied value of research in the field, the requirements submitted by employers in educational field and other chemical fields to future chemists, we found the importance of implementing the study of chemistry in an interdisciplinary context. Consequently, we have highlighted the following contradictions:

1. On the one hand, the relevant level of integration for the training of the initial professional competence of chemists, and on the other hand the lack of an interdisciplinary approach to chemistry content with other related disciplines.
2. The need to train initial professional competence at chemistry students and the lack of a methodology for the interdisciplinary competence training.

3. The integrated approach of the curriculum from the interdisciplinary perspective through chemistry, as a university discipline, as a result of highly qualified specialists training, competitive on the national and international labor market.
4. Correlation of the course contents of chemistry, biology, physics and the lack of mechanisms for achieving interdisciplinarity in the initial professional training of the chemistry student.

The contradictions determined by the need for initial training of professional competences of chemistry students and the lack of a methodology for initial training of professional competences in an interdisciplinary context resoned the research novelty and have led to the identification of the **research problem**: *What are the theoretical and methodological benchmarks of training and initial development of chemistry students in an interdisciplinary context?*

The research purpose is to determine the theoretical and methodological benchmarks of initial training / development of professional competences and the elaboration of the *Pedagogical Model of initial training of the professional competences of chemistry students in an interdisciplinary context*.

The objectives of the research are: 1) identifying the conditions and factors for integrating scientific content in the specialties of Chemistry, Chemistry and Biology, Biology and Chemistry in order to make more efficient the process of initial training of professional competences in an interdisciplinary context; 2) elaborating the *Pedagogical Model of initial training of the professional competences of chemistry students in an interdisciplinary context*; 3) designing interdisciplinary integrated contents and elaborating of the methodology for implementing the interdisciplinary curriculum on free choice *Chemistry for life - integrated research*; 4) validating through pedagogical experiment of the model and methodology designed at the interdisciplinary course on free choice *Chemistry for life - integrated research*.

The synthesis of the research methodology and validation of the chosen research methods:

- *theoretical methods:* analysis and theoretical synthesis; description; comparison; systematization; generalization; theoretical modeling;
- *praxiological methods:* questioning; testing; criterion evaluation in complex situations;
- *pedagogical experiment* (pre-experiment / diagnostical; ascertaining; formative; control);
- *chemical experiment:* identification of metal salts generating complexes and ligands of organic nature for the new compounds assembly; synthesis of coordination compounds;
- *physico-chemical experiment:* determination of the composition and structure of the compounds (element analysis; IR spectroscopy; single-crystal X-ray analysis); use of sensors (digital laboratory, which includes the sensor set and specialized NeuLog software);
- *biological experiment:* testing the biological properties of some fungal strains when introducing the coordinating compounds in the nutrient medium (deep cultivation in a nutrient medium with a previously chosen composition; photocolorimetric determination of amylolytic activity);
- *quantum-chemical experiment*: SCF method in ROHF approximation, using for atomic functions the base 6-31n (ROHF/6-31G (d)); Density Functional Theory (DFT) with the B3LYP hybrid

exchange-correlation functional (Becke with the functional correlation of three parameters Lee, Yang and Parr);

- *statistical methods:* data collection; comparison of the averages of two samples;
- *methods of analysis:* qualitative and quantitative interpretation of the experimental results using mathematical-statistical methods.

The novelty and scientific originality of the research are justified by the elaboration of an initial training model of professional competences in chemistry in an interdisciplinary context, which differs from the existing models by implementing interdisciplinary links between chemistry, computer physics and biology, necessary to form initial professional competences in chemistry design of integrated content and interdisciplinary curriculum for chemistry students: *Chemistry for life - integrated research*.

The scientific problem solved in the paper consists in theoretical and methodological demonstration through the functionality of the *Pedagogical Model of initial training of the professional competences of chemistry students in an interdisciplinary context* through the interdisciplinary curriculum: *Chemistry for life - integrated research*, focused on the initial training of future teachers' professional competences of and specialists in chemistry.

The theoretical significance of the investigation lies in the analysis, specification and establishing theoretical benchmarks produced by interdisciplinary ties on the initial training process of professional competences of future specialists in chemistry through the functionality of the Model, thus solving the problem of initial training of professional competences in chemistry in an interdisciplinary context at *Chemistry for Life - research integrated* course.

The applicative value of the research is argued by the establishment and demonstration of the theoretical-methodological benchmarks of training and development of professional competences through the functionality of the *Pedagogical Model of initial training of the professional competences of chemistry students in an interdisciplinary context* and implementation of the *Chemistry for Life - integrated research* training program within the curriculum, which contributes to initial training professional competences in chemistry in an interdisciplinary context.

Main scientific results offered for defense:

- The argumentation of the methodological dimension of the initial professional competences, as well as their interdisciplinary approach will contribute to the professional training of the chemist student, as well as to a successful social and professional insertion.
- Determining the five competencies necessary for professional training: *Investigation competence, Vocational communication competence, Ecological education competence, Digital competence*, *Continuing education competence* proves the need to design curricular contents from an interdisciplinary perspective.
- The elaboration and implementation of the *Pedagogical Model of initial training of the professional competences of chemistry students in an interdisciplinary context* proves the progress in the student formation / development in a professional setting in terms of constructivist approaches.

• The elaboration of the Interdisciplinary Curriculum *Chemistry for life - integrated research* is an effective way of initial training of professional competences at chemistry students.
• Experimental validation of elaborated Model and methodology efficiency.

The implementation of the scientific results was achieved by introducing the methodology elaborated during the interdisciplinary course teaching *Chemistry for Life - integrated research* within the pedagogical experiment conducted on a sample of intrasubjects, where undergraduate students were involved (initial training programs): Chemistry, Chemistry and biology, biology and chemistry of Tiraspol State University.

Approval and validation of scientific results is ensured by the meetings of the Chair of Chemistry of the State University of Tiraspol (based in Chisinau) jointly with the Department of Didactics in Science, within the continuous training courses of chemistry school teachers; through publications at national and international scientific conferences.

Publications on the topic of the thesis: 19 scientific papers, of which 5 articles in journals listed in the national register of scientific journals, category C; 5 articles in foreign magazines (of which 2 with impact factor); 2 papers at national scientific conferences; 3 papers at national scientific conferences with international participation; 3 papers at international scientific conferences; Guide for the use of sensors in the chemistry training process.

Dissertation volume and structure: introduction, 3 chapters, general conclusions, bibliography of 163 titles, 158 pages of basic text, 37 tables, 48 figures, 14 annexes.

Keywords: competence, professional competence, integration, interdisciplinarity, interdisciplinary curriculum, Pedagogical model of initial training, methodology on initial training of competence.

CONTENT OF THE THESIS

The **Introduction** conveys the actuality of the research topic and its importance, describes the situation in the field of research. The research problem, the purpose and objectives of the research, the scientific research methodology, the main scientific results, the scientific novelty and originality, the solved important scientific problem, the theoretical importance and the applicative value, the implementation of the results and the approval of the obtained results are conveyed.

Chapter 1 Psycho-pedagogical benchmarks in the initial training of professional competences of the chemistry student presents the theoretical study on the analysis of the concepts competence, professional competence, the typology of specific competencies, the specifics of the initial professional competence formation. Analysis of the integration concept: mono-, multi-, inter-, transdisciplinary and determination of the conditions for integration of scientific contents specific to the specialties Chemistry, Chemistry and Biology, Biology and Chemistry. In the Republic of Moldova, the concept of competence has been used since 1996, after the implementation of the Pre-University Education Reform, which aimed at modernization by developing new educational standards and curricula focused on competences [1]. For the first time, the term competence was used in 1959 by R. W. White [2] as a concept to motivate employee performance. In 1970, Craig C. Lundberg defined the concept in "Planning the Executive Development Program". In his work Testing for competence rather than for intelligence deals with the term longer (1973). Next, the term is used more widely and popularized by Richard Boyatzis and many others, such as T. F. Gilbert (1978), who used the concept in connection with increasing performance [3]. Thus, a competence is a set of defined behaviors, which allows the identification, evaluation and development of individual employee behaviors.

The concept of *competence* was introduced in education, being taken from other fields (psychology, linguistics, work psychology, etc.) and is a polysemantic notion, changing its meaning depending on the field in which it is applied. *Competence* in the Illustrated Universal Dictionary of the Romanian Language [4] is defined as *the ability to decide on a thing, based on full knowledge of the problem*. Knowledge is the necessary basis of competence, and experience is the continuous path in changing the acquired knowledge. Thus, competence is always more than just knowledge or experience [5]. Researcher И. А. Зимняя [6] analyzes competences as knowledge, representations, actions, systems and relationships, which are then developed into personality competences. In the source [7, p. 77], *competence is the result of the complete processing of a situation by a person or a group of people, in a given context*.

X. Roegiers' approach to competence is a pragmatic one, which is presented as *an integrated set of knowledge, competences, attitudes practiced spontaneously* [8]. The Education Code of the Republic of Moldova [1] states: *the main purpose of education is the integrity formation and the development of a skill system that include knowledge, competences, attitudes and values that allow the active participation of the individual in social and economic life*. The Framework for National Curriculum [9] as an educational policy document, presents the concept of competence as a complex and integrated system of knowledge, competences, attitudes and values, formed and developed in the educational process, whose involvement allows the identification and resolution of different problems in different contexts and situations. So, *competence* according to various approaches and interpretations is a complex educational purpose, determined by the system of knowledge, competences, attitudes and values.

The Qualifications Framework for Higher Education [10] defines professional competence as *a proven ability to select, combine and use knowledge, competences, values and attitudes appropriately in order to successfully solve a certain category of circumscribed work or learning situations, restricted to that profession, in terms of effectiveness and efficiency*.

In its turn, *professional competence* is the result of professional experience, being observable during professional activity. D. Salade considers that professional competence represents the optimal accordance between the individual's abilities, working conditions and the result of their activity. For S. Marcus, the effective exercise of the activity is the basis of the behavior, being conditioned by a complex of qualities specific to the entire internalized structure of the individual [11].

According to pt. 10 of HGM 193/2017 [12] concerning the professional training of adults, *professional competence* consists in the ability to apply, transfer and combine knowledge and competences in various situations and work environments to perform the activities necessary at the place of work having the quality level specified in the occupational standards. Thus, professional competences are formed and developed through initiation, qualification, improvement, specialization, retraining. The European Qualifications Framework describes competence from the perspective of responsibility and autonomy. Along with the qualification attesting to a standardized training, the unique qualities that an individual must possess and which allow him to adapt to new work situations have begun to be highlighted [13]. Э. Ф. Зеер [14] defines *professional competence* as the totality of professional knowledge and competences, as well as ways of performing practical work. Л. Н. Журбенко [15] presents the concept of *professional competence* as an integrated set of basic and professionally relevant knowledge of the specialty that ensures their efficient use in the workplace.

Professional competence is characterized as an integral system, which manifests itself and is formed in professional activity, based on knowledge, competences, personal qualities and values, which allows it to establish links between knowledge and the real situation, determining the system of specific actions for effective problem solution [16]. In the vision of researchers Vl. Guţu, O. Dandara, E. Muraru, professional competence represents the capacity / ability to perform various tasks determined by professional activity, the ability to solve certain problem situations by transferring and integrating knowledge, competences and attitudes [17]. Psychologist Ig. Racu states that *professional competence* highlights the person's ability to integrate theoretical knowledge with practical competences and their own ability to think, analyze and synthesize, to perform activities and obtain results at a qualitative level [18]. The Standards for the continuous training of teachers in general secondary education stipulate that the system of *professional competences* represents an integrated system of competences (basic, areas of competence, specific competences) focused on the professional training of teachers [19].

The *professional competence* has attributions in the fields of education, from the pedagogical point of view, being characterized by the dimensions that complete it, and being made of a set of capacities, abilities and attitudes, which interacting with the pedagogue's personality, will attribute his professional qualities, ensuring the fulfillment of the objectives of the educational process, and the performances which correspond to the intellectual level of the students [20]. In the view of researchers, as well as based on educational policy documents, *the concept of professional competence is a system of knowledge, competences, abilities (experiences), attitudes and personal values manifested in professional activity to achieve certain contextual situations.* The initial training of students involves certain components with the status of fundamental factors in the educational process. The final product acquired by the student is expressed in the form of professional competence by integrating *knowledge* (cognitive field), *abilities* (psychomotor field), *attitudes and values* (affective-attitudinal field). *The professional competence of the chemistry student* is an integral feature, which will determine the development of the abilities of the chemistry specialist to be able to solve specific professional tasks and problems, which will appear in real situations of professional activity, using knowledge, competences, life experience and personal qualities.

Chapter 2 The methodological framework for initial training of professional competences of chemistry students the *Pedagogical Model of initial training of the professional competences of chemistry students in an interdisciplinary context* is through the following dimensions: organizational-regulatory and instrumental-methodological. There are described structural components of the interdisciplinary curriculum on free choice C*hemistry for life - integrated research* and the approaches to designing interdisciplinary scientific content are analyzed. The theoretical and methodological benchmarks *of initial training of the professional competences of chemistry students in an interdisciplinary context* are exposed. For the university training of future specialists in the field of chemistry, the specialization component is important both for the cognitive development of students and for the initial professional training processes. The training of future specialists in the field of chemistry is designed to develop in students the competences to achieve the interdisciplinary approach to chemistry with biology, physics, and computer science [21]. According to researchers Vl. Guțu, N. Silistraru and others. the university curriculum is a set of official documents, which are intended to establish and regulate the unitary reference framework, at the level of a higher education institution, focusing on competencies, contents, learning, assessment and research activities on which basis the university educational process is organized [22]. *The aim of the research* is to determine the theoretical and methodological benchmarks of initial training / development of professional competences and the development of the *Pedagogical Model of initial training of the professional competences of chemistry students in an interdisciplinary context* (Figure 2.1), which highlighted the structural components of the initial competences training model necessary for the chemistry student.

In order to achieve the projected goal, the following *objectives* were highlighted:

1) identifying the conditions and factors for integrating scientific content in the specialties of Chemistry, Chemistry and Biology, Biology and Chemistry in order to make more efficient the process of initial training of professional competences in an interdisciplinary context;
2) elaborating the *Pedagogical Model of initial training of the professional competences of chemistry students in an interdisciplinary context*;
3) designing interdisciplinary integrated contents and elaborating of the methodology for implementing the interdisciplinary curriculum on free choice *Chemistry for life - integrated research*;
4) validating through pedagogical experiment of the model and methodology designed at the interdisciplinary course on free choice *Chemistry for life - integrated research*.

In order to valorify the proposed purpose and objectives, we analyzed some models of professional competences training and found that no author has referred to the training of the following professional competences of the chemistry student in an interdisciplinary context: *Investigative competence, Professional communication competence, Digital competence, Ecological competence, Continuing professional training competence*.

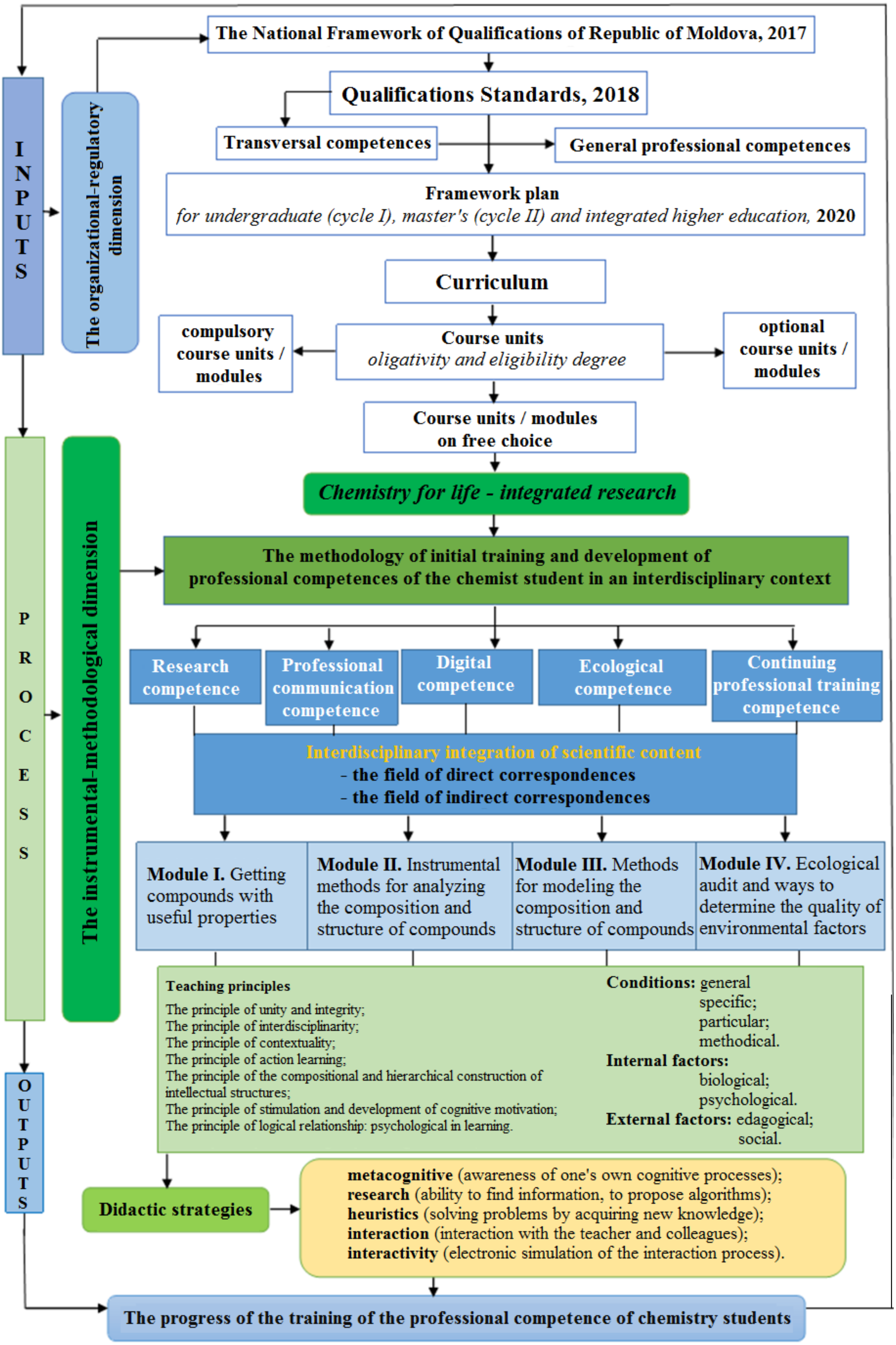

Fig. 2.1. The Pedagogical Model of initial training of the professional competences of chemistry student in an interdisciplinary context

The essential idea of the conception formulated in the *Pedagogical Model of initial training of the professional competences of chemistry students in an interdisciplinary context* is the development of an efficient methodology for initial formation of the professional competencies necessary for chemistry students in interdisciplinary context. The model is based on two dimensions: *organizational-regulatory* and *instrumental-methodological*.

Organizational-regulatory dimension: refers to the regulatory documents of the university system: The National Framework of Qualifications (2017) [23]; Training standards for specialists (2018) [24]; Framework plan for undergraduate (cycle I), master's degree (cycle II)

and integrated higher education, 2020 [25]; Curriculum of higher education and structuring curricula by the following components: course units (*compulsoriness and eligibility degree*) [26].

The instrumental-methodological dimension is focused on the methodology of training the initial professional competence of the chemistry student in an interdisciplinary context by designing and implementing the interdisciplinary curriculum *Chemistry for life - integrated research*. The purpose of the Model is the progress of the training of the professional competence of chemistry students. Professor Valeriu Cabac argues that *focusing training programs on study purposes* is a new concept, a new form of design of the teaching process, which includes two central directions: 1) placing the student at the center of the training process, and 2) makes it possible to explain the extension of the competence concept in the field of education [27].

The aim of the integrated curriculum aims at training the professional competences of chemistry students by acquiring specific competences: *Investigative competence, Professional communication competence, Digital competence, Ecological competence, Continuing professional training*, which are necessary in the context of social integration and in preparing chemistry students for developing their own career project. The curriculum was designed as one on free choice, of extension and knowledge deepening and integrated training-assessment activities, designed for the disciplinary courses, as chemistry, biology and chemistry, chemistry and biology, chemistry and physics. The curriculum is structured in four learning units: *Obtaining of compounds with useful properties; Instrumental methods for analyzing the composition and structure of compounds; Methods for modeling the composition and structure of compounds, Ecological audit and ways to determine the quality of environmental factors*.

Disciplinary integration can be achieved on the basis of two areas: *the area of direct correspondence* and *the area of indirect correspondence.*

The area of direct correspondences refers to the correspondence between the didactic structure of the taught subject and the logical structure of the science it reflects, i.e., the educational object reflects the boundaries and concepts of the science it represents.

The area of indirect correspondences concerns sets of cognitive structures from different sciences, leading to a new content whose configuration can no longer be recognized in each of the sciences that were at the starting point [28].

Analyzing the study programs of the specialties with chemical profile, proposed within the Faculty of Biology and Chemistry at TSU, it was found that in the instructive-educational process of teaching-learning, interdisciplinary courses are used, the latter appeared after the interpenetration of chemistry with other disciplines [26]. Depending on the specialty, the curricula include interdisciplinary disciplines: Biological Chemistry, Physical Chemistry, Hydrochemistry, Histoembryology, Agrobiology, Ecology, Biogeography, Crystallochemistry, Radiochemistry, Ecological Chemistry, Hydrobiology, Astrophysics, Agrochemistry, Psychophysiology etc.

Based on the analysis, we can see that practically all specialties of the Faculty of Biology and Chemistry of TSU, the implementation rate of interdisciplinary courses is within the 8.05 - 12.73%. The highest degree of interdisciplinarity (12.73%) was attested in the specialty of Ecology (full-time studies), because the study of ecology leads to the formation of a self-culture, ecological awareness that is based on the development of specific competences and contents in an inter / transdisciplinary view. Within the integrated study, the informational amount of notions, theories is increased and the unitary scientific picture of the world is formed, which possesses dialectical integrity. Namely in the intersection areas of different scientific branches, there are premises for the study of complex phenomena [29].

Compared to traditional higher education, which is focused on specific knowledge of the field and the development of general competences, this type of higher education aims to develop competences which to cross disciplinary boundaries, the latter consist in the ability to change perspectives, to synthesize knowledge from different disciplines. and cope with complexity.

These scientific arguments prove the effectiveness of interdisciplinary content approaches in the training of chemists.

Chapter 3 Experimental argumentation of the efficiency of the model and methodology of initial training and development of professional competences of the chemist student in an interdisciplinary context describes the design and development of the pedagogical experiment: pre-experiment stage, ascertaining and training experiment and there are performed qualitative and quantitative statistical analyses of the results obtained by using mathematical methods of qualitative and quantitative determination, indicators for assessing the training levels of professional and specific competences.

The methodological dimension of *The Pedagogical Model of initial training of the professional competences of chemistry students in an interdisciplinary context* is represented by the *Technology of the professional competencies training of the chemist student in interdisciplinary context*, which capitalizes and enhances the theoretical dimension of the Model.

In this logic, the pedagogical experiment had as the **major objective** *the validation by experiment of the Technology of the professional competencies training of the chemist student in interdisciplinary context*, having as basic criterion the specific competences: *investigation, professional communication, digital, ecological, continuous training*, demonstrated by chemistry students in the process of solving significant situations, with interdisciplinary character, created within the training activities. The pedagogical experiment included 4 stages: *diagnostic/pre-*

experiment stage, ascertaining, formative, control. In accordance with the purpose of the research, the following **objectives of the pedagogical experiment** were established:

1. Ascertaining the attitude of chemistry students if there is the need for the interdisciplinary course Chemistry for Life - integrated research, as well as expectations in this context.
2. Determining the initial level of the specific competencies of the chemistry student in the professional field (the stage of ascertaining).
3. Description of the training experiment in curricular context of the specific competencies necessary for the chemistry student (see model).
4. Experimental validation of the efficiency of experimental scientific results obtained by using mathematical-statistical methods.

In order to determine the attitude of chemistry students towards the opportunity of training professional competences in the interdisciplinary course *Chemistry for Life - Integrated Research*, as well as their expectations in this context, the questionnaire method was used.

The experimental sample was a group of first and second year students from the specialties of *Chemistry*, *Chemistry and Biology*, *Biology and Chemistry* (full-time education) and *Chemistry* (part-time education) a total of 102 respondents. The questionnaire included 10 items.

Item 1. What notion would be more appropriate for professional competence in your opinion?

Based on the analysis of the answers presented by students, it was difficult to highlight a unanimous definition of professional competence. The results for this item were systematized in Table 3.1 and illustrated in Figure 3.1.

Table 3.1. Definitions of compentece

Number	Complete response for the definition		Partial response		Wrong response	
	Students, nr.	Ratio, %	Students, nr.	Ratio, %	Students, nr.	Ratio, %
102	34	33,33	43	42,16	25	24,51

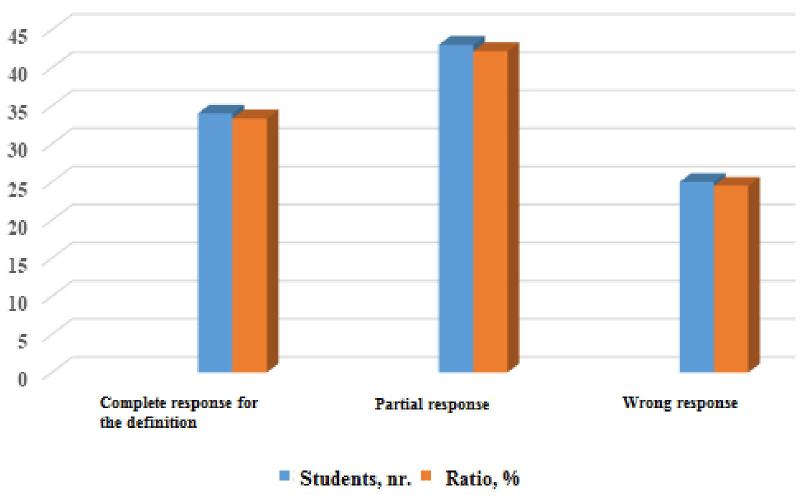

Fig. 3.1. Ratio in highlighting the definition of competence

From what was enunciated by the students, we found that *professional competence* is a system *of structured knowledge, competences and attitudes*. Students confuse the definition of *professional competence*, often stipulating its elements.

As it was stated above, they correctly set out the definitions:

- Ability to apply, transfer and combine knowledge and competences in various work situations and environments;
- The capacities of a specialist in a particular field.

In conclusion, in the students' view, competence is defined by three types of features: *knowledge, competences and attitudes*.

Item 2. List some elements (components) of professional competence

Competence appears as a *distinct learning outcome*, different from knowledge and competences. As for the roles, tasks and problem situations to be solved, the students listed various types of competences that are shown in Figure 3.2.

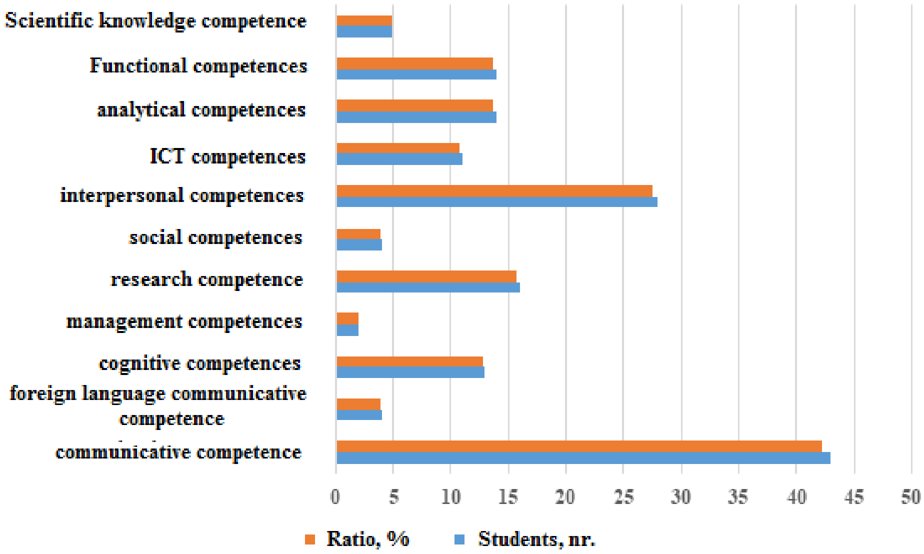

Fig. 3.2. The Ratio of the elements of professional competence

The elements of professional competence listed by chemistry students, necessary for carrying out a teaching activity and which contribute to the achievement of the proposed objectives are different.

The objective of the ascertaining experiment is to determine the initial level of specific competences training of the chemistry student until the implementation of the interdisciplinary curriculum *Chemistry for Life - integrated research* and the level of scientific knowledge integration obtained separately in study programs.

The experimental group consisted of *31 first and second year students at the specialties of Chemistry, Chemistry and Biology, Biology and Chemistry (full-time education).*

We mention that the pedagogical experiment was a *natural* one, with specific teaching activities in their usual environment; *specific* - performed during 12-week internships; after a period of time it is a long-*term experiment*; according to the sampling technique, it is of *experimental design intra subjects*, which *involves following the subjects in all stages of the pedagogical experiment and their evolution analysis*. The pedagogical experiment was a *systematic* one, organized and carried out within the Faculty of Biology and Chemistry of the Tiraspol State University, Chisinau city. The *ascertaining* took place in September 2019, before the implementation of the course *Chemistry for Life - Integrated Research*.

Analysing the answers offered by the subjects involved in the experiment, the distribution was made on levels according to the indicators, by applying the evaluation degrees (in percentages) and the quality of the products was found, as N I (high); N II (satisfactory, average); N III (lower than average), shown in Figure 3.3.

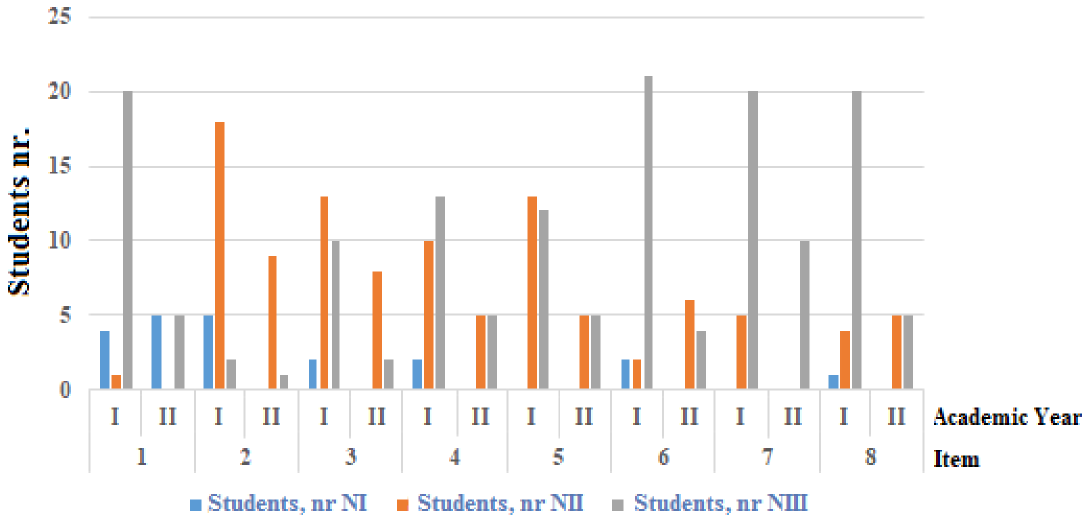

Fig. 3.3. The results of the initial evaluation (ascertainment stage)

The lack of software use specific to the field of Chemistry in pre-university cycles was found in the answers to item 6, in which 25 students (71.43%) said they did not know or felt confused with some applications, elementary programs they know from the course school computer science are: Word, Excel, PowerPoint, and 8 students (22.86%) named some specific applications for Chemistry: ChemDraw, ChemBioDraw, ChemLab, ChemixSchool, Molec. Mass. Calc. and only 2 (5.71%) proved that they know how to use these applications: writing molecular and structural formulas of chemical compounds, calculating the molecular weight of chemical compounds, virtual chemistry laboratory. At item 7 (30 people, 85.71%) do not know any methods of modelling the composition and structure of chemical compounds, and those who know (5 people, 14.29%) referred to archaic modelling (ball-axis). Most of them (25 people, 71.43%), item 8, answered that they do not know any digital applications that can be used to determine the quality of environmental factors, and those who know (10 people, 28.57%) referred to sensors, digital barometers, nitrate level detectors in fruits and vegetables.

We have to specify that the *Technology for training the professional competencies of the chemistry student in an interdisciplinary context* served as a theoretical-methodological basis for the elaboration of the Interdisciplinary Curriculum *Chemistry for life - integrated research*. It was implemented in the experimental training group during September-November 2019. The implementation of the Interdisciplinary Curriculum *Chemistry for Life - integrated research* was done through various interactive strategies, which are based on learning situations, through which the student assimilates interdisciplinary content and forms its system of competencies.

In the context of the constructivist approach, we observed the following basic requirements of learning:

- **The learning process is of mental construction**, ie it is a process based on which an internal representation of the surrounding world is consecrated.
- **The interpretation is personal**, ie each student builds his own interpretation on reality. It is important that such an interpretation always starts from reality.
- **Learning is active**, involves the student's involvement in seeking, processing, understanding and developing knowledge and relationships.
- **Learning involves collaboration**, ie it becomes dependent on interpersonal relationships and communication with others.
- **Learning is contextual**, ie the learning process must take place in situations that are significant for students and relevant to the context in which the new information will be used later [30].

For the control stage of the pedagogical experiment, we set the *objective*: *to determine the level of training of the professional competencies necessary for the chemistry student at the control / post-training stage*. 31 students participated at the control stage, where it was also applied a questionnaire consisting of 8 items, where compared to the ascertaining stage the items had an applicative content and the evaluation results are shown in Figure 3.4.

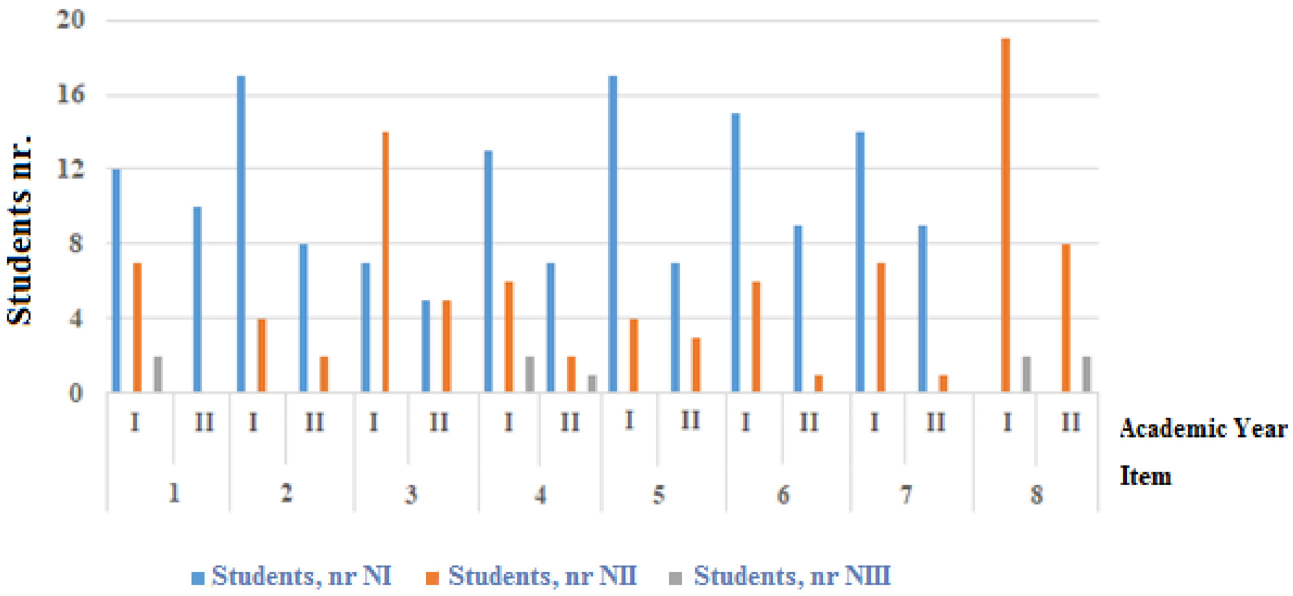

Fig. 3.4. The results of the final evaluation (control stage)

Thus, both first year and second year students gave answers predominantly to NI and NII. Compared to the ascertaining stage, the answers had a deeper, conscious, logical and more relevant content.

In order to demonstrate the efficiency of the designed model and of the proposed methodology, in the process of implementing in the teaching process, two current evaluations and the final evaluation was performed within the course on free choice *Chemistry for life - integrated research*. The results were statistically analysed using the t-student tests (for paired samples) and Wilcoxon (rank test) [31].

Because the course on free-choice *Chemistry for Life - Integrated Research* was experimentally implemented only in a group of students who studied it voluntarily, it was necessary to apply the t-student test for paired samples according to the process of comparing scores to a variable in different experimental conditions. We note here that the conditions imposed for performing this test were met: the dependent variable (marks obtained in tests) is quantitative; the dependent variable is normally distributed (Figure 3.5); the independent variable (subjects of the experimental sample) is dichotomous, and the groups are pairs (the same subjects in different experimental situations).

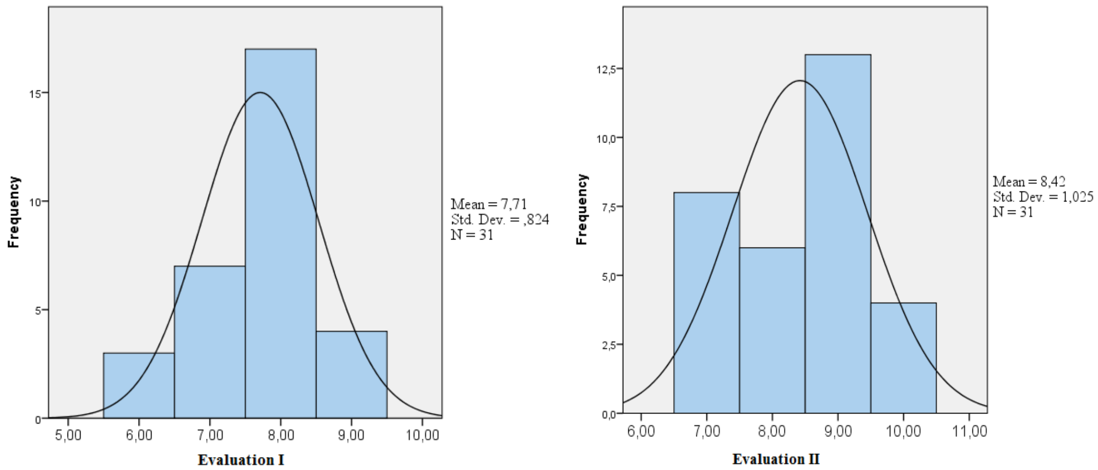

Fig. 3.5. Normality of results distribution in evaluation I and II

Below we present the results of the *t-student* test to compare the marks at assessment I with those at assessment II.

Table 3.2. T-test for paired samples: evaluation 1 - evaluation II

Paired Samples Statistics (1)					
		Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Pair 1	mark for the evaluation 1	7,7097	31	,82436	,14806
	mark for the evaluation 2	8,4194	31	1,02548	,18418
Paired Samples Correlations (2)					
Pair 1			**N**	**Correlation**	**Sig.**
	mark for the evaluation 1 & mark for the evaluation 2		31	,819	,000
Paired Samples Test (3)					

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	mark for the evaluation 1 mark for the evaluation 2	-,70968	,58842	,10568	-,92551	-,49384	-6,715	30	,000

The first table (*Paired Samples Statistics*) shows for each of the two variables - averages, number of subjects, standard deviations and standard errors of the averages. We notice that the average for evaluation I is 7.7 and for evaluation II - 8.4. The second table (*Paired Samples Correlations*) shows the correlation coefficient between the variables *mark for assessment 1* and *mark for assessment 2*, where r(29) = 0.819 and the associated significance threshold p = 0.000 (<0.001), which means that there is a positive correlation between the two variables. The third table (*Paired Samples Test*) reflects the main results of the t-test, namely: t (30) = 6.715, and p = 0.000 (<0.05), statistically significant. These data point to a significant difference between the results of evaluation I and evaluation II, the average from evaluation II being significantly higher compared to the average from evaluation I. The significant difference is also confirmed by the fact that the difference between the averages (0.7) is falls within the limits of the confidence interval (with a probability of 95%), an interval that does not contain the value zero. Based on the results obtained, the effect size (d) can be calculated:

The first table (*Paired Samples Statistics*) shows for each of the two variables - averages, number of subjects, standard deviations and standard errors of the averages.

We notice that the average for evaluation I is 7.7 and for evaluation II - 8.4. The second table (*Paired Samples Correlations*) shows the correlation coefficient between the variables *mark for assessment 1* and *mark for assessment* 2, where r(29) = 0.819 and the associated significance threshold p = 0.000 (<0.001), which means that there is a positive correlation between the two variables. The third table (*Paired Samples Test*) reflects the main results of the t-test, namely: t(30) = 6.715, and p = 0.000 (<0.05), statistically significant. These data point to a significant difference between the results of evaluation I and evaluation II, the average from evaluation II being significantly higher compared to the average from evaluation I. The significant difference is also confirmed by the fact that the difference between the averages (0.7) falls within the limits of the confidence interval (with a probability of 95%), an interval that does not contain the value zero. Based on the results obtained, the effect size (d) can be calculated:

$$d = \sqrt{\frac{t^2}{df}} = \sqrt{\frac{t^2}{N-1}} = \sqrt{\frac{6{,}715^2}{31-1}} = 1{,}2 \qquad (3.1)$$

Since $d \geq 1$, it turns out that the experimental approach had a *very strong* effect on increasing learning outcomes, from the first assessment to the second.

The same test was applied to compare the results of the first and final evaluation, and the results obtained are illustrated in Table 3.3.

Table 3.3. T-test for paired samples: evaluation 1 - final evaluation

Paired Samples Statistics (1)					
		Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Pair 1	mark for the evaluation 1	7,7097	31	,82436	,14806
	mark for the final evaluation	8,2194	31	,74360	,13356

Paired Samples Correlations (2)				
Pair 1		**N**	**Correlation**	**Sig.**
	mark for the evaluation 1 & mark for the final evaluation	31	,803	,000

Paired Samples Test (3)									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	mark for the evaluation 1 - mark for the final evaluation	-,50968	,49756	,08937	-,69219	-,32717	-5,703	30	,000

And in this case (the average at evaluation I is 7.7, and at the final evaluation - 8.2194) there is a positive correlation between the two variables (r(29) = 0.803, p = 0.000 (<0.001)), and the results of the t-test (t (30) = 5,703, p = 0.000 (<0.05)) shows a difference between the results at evaluation I and the final evaluation, the average from the final evaluation being significantly higher compared to the average from evaluation I from the results obtained the effect size (d) can be calculated:

$$d = \sqrt{\frac{t^2}{df}} = \sqrt{\frac{t^2}{N-1}} = \sqrt{\frac{5{,}703^2}{31-1}} = 1{,}04 \qquad (3.2)$$

The effect size calculated according to the obtained results is $d = 1{,}04$ (≥ 1), which indicates that the experimental intervention had a very strong effect on the increase of learning outcomes, from the first assessment to the final one. Another situation is attested when we compare the averages at the evaluation II and the final one (Table 3.4).

Table 3.4. T-test for paired samples: evaluation 2 - final evaluation

Paired Samples Statistics (1)					
		Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Pair 1	mark for the evaluation 2	8,4194	31	1,02548	,18418
	mark for the final evaluation	8,2194	31	,74360	,13356
Paired Samples Correlations (2)					

Pair 1		N	Correlation	Sig.
	mark for the evaluation 1 & mark for the evaluation 2	31	,846	,000

Paired Samples Test (3)									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	mark for the evaluation 2 - mark for the final evaluation	,2000	,56095	,10075	-,00576	,40576	1,985	30	,056

We note that although there is a positive correlation between the researched variables (*mark for the evaluation 2* and *mark for the final evaluation*) r(29) = 0.846 and p = 0.000 (<0.001), however, this is a very weak one. The t-test results (t(30) = 1.985, p = 0.056 (> 0.05)) are statistically insignificant, indicating that the averages at the assessment II and the final assessment do not differ significantly from each other. The insignificant difference is also confirmed by the fact that (with a probability of 95%) the confidence interval (-0.005; 0.405) contains the value zero.

This ascertaining can be explained by the fact that the subjects included in the final assessment cover the entire course content and contain a large volume of information, which requires highly developed learning skills, or at a completely new course, this is difficult to achieve.

$$d = \sqrt{\frac{t^2}{df}} = \sqrt{\frac{t^2}{N-1}} = \sqrt{\frac{1{,}985^2}{31-1}} = 0{,}36 \qquad (3.3)$$

The effect size d = 0.36 is between 0.2 and 0.5, which indicates that the effect of the intervention program on the decrease of the average from the evaluation II to the final one is weak.

On the other hand, the results of the t-test in this case may not be conclusive because the variable grade at the final assessment is not normally distributed, as can be seen in the figure below (does not fall below the normal curve), and these results will be challenged by another statistical test, more robust than normal distribution.

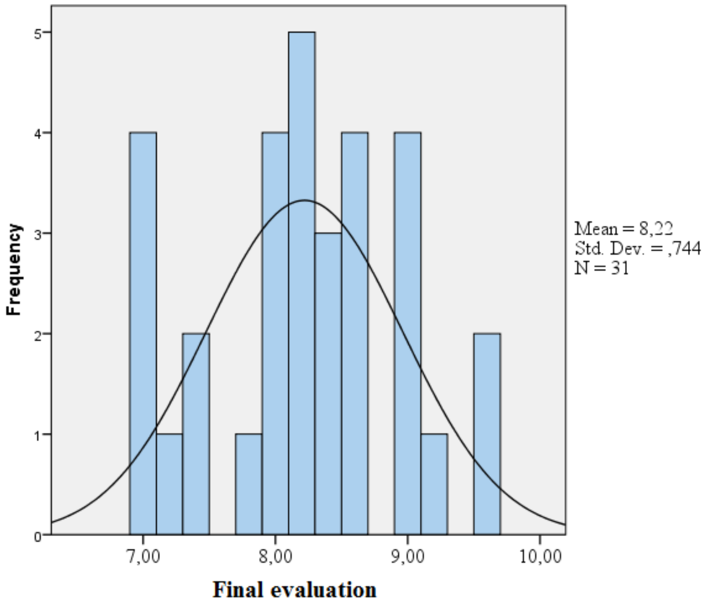

Fig. 3.6. Normal distribution of results at the final evaluation

To confirm the results described above, the literature recommends applying at least one more statistical test, and in the case of this research the Wilcoxon test was used to compare two pairs of variables, because the experimental sample has a relatively small number of subjects and the minimum test requirements are met: the samples are paired and the dependent variable is quantitative [31].

The Wilcoxon test is based on comparing the averages of the ranks, as in the case of the Mann-Whitney test, only that the ranks are determined by the difference between the scores of the variables examined for each subject, taking into account the sign of difference (positive or negative). As a result of the application of this test, it was determined whether the application of the methodology developed on an experimental group of 31 students led to the registration of academic success from the first to the final evaluation.

Table 3.5. Wilcoxon test for evaluation 1 - evaluation 2

Ranks (1)

		N	Mean Rank	Sum of Ranks
mark for the evaluation 2 mark for the evaluation 1	Negative Ranks	2[a]	13,50	27,00
	Positive Ranks	24[b]	13,50	324,00
	Ties	5[c]		
	Total	31		

a. mark for the evaluation 2 < mark for the evaluation 1
b. mark for the evaluation 2 > mark for the evaluation 1
c. mark for the evaluation 2 = mark for the evaluation 1

Test Statistics[a] (2)

	mark for the evaluation 2 - mark for the evaluation 1
Z	-4,315[b]
Asymp. Sig. (2-tailed)	,000

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.

The Wilcoxon test for two pairs of variables was implemented as in the case of the t-student test, to compare the results between assessment I and assessment II (Table 3.5), to compare the results between assessment I and final assessment (Table 3.6) and to compare the results between evaluation II and final evaluation (Table 3.7).

The Ranks table shows the sum and average of the positive and negative ranks, calculated for the indicated number of subjects (only two negative ranks are attested). The main test results are reflected in the *Test Statistics* table and because z = - 4,315 and p = 0.000 (<0.05), it results that there are significant differences between the evaluation I average and the evaluation II average. The difference is determined by analyzing the values of the rank sum in the *Ranks* table. The maximum value corresponds to the positive ranks, being 324.00 which means that there are significantly more situations in which the mark at evaluation II is higher than the mark at evaluation I (24 compared to 2).

The size of the effect calculated according to these results is:

$$r = \sqrt{\frac{z^2}{N}} = \sqrt{\frac{4,315^2}{31}} = 0,775 \qquad (3.4)$$

and because it is greater than 0.7 (according to the reference values set by Cohen), the effect proves to be very strong.

These findings confirm the results of the t-student test, therefore there was academic success from the first assessment to the second, and the experimental intervention to implement the developed methodology had a positive effect.

Table 3.6. Wilcoxon test for evaluation 1 - final evaluation

Ranks (1)

		N	Mean Rank	Sum of Ranks
mark for final evaluation - mark for evaluation 1	Negative Ranks	3[a]	10,67	32,00
	Positive Ranks	26[b]	15,50	403,00
	Ties	2[c]		
	Total	31		

a. mark for final evaluation < mark for evaluation 1
b. mark for final evaluation > mark for evaluation 1
c. mark for final evaluation = mark for evaluation 1

Test Statistics[a] (2)

	mark for final evaluation - mark for evaluation 1
Z	-4,042[b]
Asymp. Sig. (2-tailed)	,000

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.

Table 3.6 presents the results confirming the findings following the application of the Wilcoxon test for evaluation I and the final evaluation, namely (z = - 4,042; p = 0,000) that there are significant differences between the evaluation I average and the final evaluation average, in favour of the latter, because the sum of the highest ranks is 403.00 and corresponds to the positive ranks, and the effect is very strong ($r = 0,726 \geq 0,7$).

$$r = \sqrt{\frac{z^2}{N}} = \sqrt{\frac{4{,}042^2}{31}} = 0{,}726 \qquad (3.5)$$

Table 3.7. Wilcoxon test for evaluation 2 - final assessment

Ranks (1)

		N	Mean Rank	Sum of Ranks
mark for final evaluation - mark for evaluation 2	Negative Ranks	13[a]	11,27	146,50
	Positive Ranks	6[b]	7,25	43,50
	Ties	12[c]		
	Total	31		

a. mark for final evaluation < mark for evaluation 2
b. mark for final evaluation > mark for evaluation 2
c. mark for final evaluation = mark for evaluation 2

Test Statistics[a] (2)

	mark for final evaluation - mark for evaluation 2
Z	-2,106[b]
Asymp. Sig. (2-tailed)	,035

a. Wilcoxon Signed Ranks Test
b. Based on positive ranks.

Table 3.7 refers to the comparison of the results of evaluation II and the final one, an analysis which did not identify significant differences between these results in the t-test. This time, because z = - 2,106, and p = 0.035 (<0.05), it results that there are significant differences between the mark of evaluation II and the mark of the final evaluation. The difference is confirmed by the analysis of the *Rank Sum* in the *Ranks* table, which states that the highest value is 146.50 and corresponds to negative ranks, ie situations where the ranks of the evaluation II variable are higher compared to the ranks of the final evaluation variable.

$$r = \sqrt{\frac{z^2}{N}} = \sqrt{\frac{2{,}106^2}{31}} = 0{,}378 \qquad (3.6)$$

However, the size of the effect $r = 0{,}378 \geq 0{,}3$, indicates, unlike the one calculated for the t-test, that there is an average effect of the intervention program on the decrease of the final evaluation average, if compared to the evaluation II.

In *conclusion*, we can say that the experimental intervention to implement the model and methodology developed following the pedagogical research and conducted by the author, generally had a positive effect, demonstrating significant differences between the averages of evaluation I, evaluation II and final evaluation (with small exceptions argued above), attesting important academic success for the subjects involved in the experiment.

GENERAL CONCLUSIONS AND RECOMMENDATIONS

The carried out theoretical and practical research allowed the identification and description of the theoretical-methodological basis for the elaboration of the *Pedagogical Model of initial training of the professional competences of chemistry students in an interdisciplinary context* ant its implementation through an optimal integration of chemistry contents with physics, biology, informatics, mathematics within the interdisciplinary (optional) course *Chemistry for life* -

integrated research, from the perspective of training the professional skills of future specialists in the field of chemistry. The obtained theoretical and experimental results led to the confirmation of the research hypothesis and the achievement of the proposed objectives which allow us to enunciate the following ***conclusions***:

1. In order to make more efficient and motivate the chemistry training process, the *Pedagogical Model of initial training of the professional competences of chemistry students in an interdisciplinary context* was developed based on the analysis of the literature, conceptual and methodological research of professional skills training.
2. The elaboration of the pedagogical model of initial training of professional competences in chemistry allowed the design of an efficient methodology for training and development of the initial professional competences of chemistry students in an interdisciplinary context. The developed methodology contributes to the development of students' cognitive activity, the accumulation of knowledge in the field of specialization and the formation of skills necessary for insertion in the professional field of activity [32].
3. In the methodology of implementation of the designed Model were claimed and justified the pedagogical and methodological conditions and premises, which influence the formation and development of initial professional skills in chemistry in an interdisciplinary context: motivational conditions, conditions for interdisciplinary integration, active and interactive learning methods.
4. Based on the proposed model, the Curriculum of the interdisciplinary course on free-choice *Chemistry for Life - integrated research* was elaborated, Guide for the use of sensors in the chemistry training process, interactive-formative assessment tests, final assessment tests, individual task sets, which allowed the content to be developed efficiently [33].
5. The Curriculum of the designed interdisciplinary course on free choice *Chemistry for Life - integrated research* aims at training the professional skills of chemistry students by acquiring the necessary specific skills, forming an integrated vision of nature, developing analytical skills and integrated thinking, and personal expression skills in debating ideas, education a tolerant attitude towards the environment [34, 35].
6. The experimental research is the basic activity in the initial training of chemistry students, and the use of contemporary information technologies specific to chemistry, in the training process open new opportunities in training and developing professional skills specific to the field, as well as for performing individual motivating tasks [36, 37].
7. The formative experiment demonstrated the efficiency of content integration in the study of the interdisciplinary course *Chemistry for Life - integrated research*. In particular, we focused on the interdisciplinary integration of content through the field of direct and indirect correspondence.
8. The realization of the pedagogical experiment allowed the ascertainment of the significant changes in the experimental group, where as a result of the implementation of the

interdisciplinary course the motivation, the involvement, the collaboration degree, the academic success of the students increased.

9. The research objectives were achieved, thus contributing to solving the **research problem**: what the theoretical and methodological landmarks of the initial training and development of the professional skills of the chemistry student in an interdisciplinary context are. The solution of the research problem and the achievement of the proposed objectives are confirmed by the results published in the research papers [21, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48] and offer the possibility to make more efficient the instructional process in chemistry, including within the interdisciplinary course *Chemistry for life - integrated research*, by integrating the contents of the discipline chemistry with physics, biology, computer science, mathematics.

According to conclusions stated above, we can make the following **recommendations**:

➢ *For teachers:*

1. In order to improve the professional activity of teachers in university and pre-university education, we propose the documentation and use of the methodology developed in accordance with the requirements of the proposed pedagogical model;
2. The efficiency of the teachers' activity in university and pre-university education will increase through the qualitative implementation of interdisciplinary contents in the educational process in chemistry, by implementing the experience gained as methodological support for continuing education in this field, by studying materials published in this section.
3. Valorisation of the methodology of initial training of professional competencies through learning activities for chemistry students in completing and modernizing the Curriculum of other specialized disciplines, elaboration of methodical works, course guides, etc.

➢ *for authors of textbooks and teaching materials:*

1. To promote at the level of school and university curriculum of interdisciplinary studies based on the use of research methods in related fields.

➢ *for students and master's students:*

1. The results obtained in the research can be implemented in the initial training of teachers in the field of chemistry by studying the pedagogical model and implementation of methodology developed for subsequent application in the teaching activity they will carry out, to complete their bachelor's and master's degree theses in personal research.

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ANNOTATION

Codreanu Sergiu**, Initial training methodology of the professional competences of the chemistry student in an interdisciplinary context. Doctoral thesis in pedagogical sciences, Chișinău, 2020**

Structure of the thesis: introduction, 3 chapters, general conclusions and recommendations, bibliography of 163 titles, 158 pages of basic text, 37 tables, 48 figures, 14 annexes. Results published in 19 scientific works.

Key concepts: competence, professional competence, integration, interdisciplinarity, interdisciplinary curriculum, Pedagogical model for initial training, technology of initial training of competence.

Field of study: Pedagogical sciences, School didactics (Chemistry)**.**

The research purpose is to determine the theoretical and methodological benchmarks of initial training / development of professional competences and the elaboration of the *Pedagogical Model of initial training of the professional competences of chemistry students in an interdisciplinary context*.

The objectives of the research: 1) identifying the conditions and factors for integrating scientific content in the specialties of Chemistry, Chemistry and Biology, Biology and Chemistry in order to make more efficient the process of initial training of professional competences in an interdisciplinary context; 2) elaborating the *Pedagogical Model of initial training of the professional competences of chemistry students in an interdisciplinary context*; 3) designing interdisciplinary integrated contents and elaborating of the methodology for implementing the interdisciplinary curriculum on free choice *Chemistry for life - integrated research*; 4) validating through pedagogical experiment of the efficiency of the model and methodology elaborated by mathematical-statistical methods.

The novelty and scientific originality of the research are justified by the elaboration of an initial training model of professional competences in chemistry in an interdisciplinary context, which differs from the existing models by implementing interdisciplinary links between chemistry, computer physics and biology, necessary to form initial professional competences in chemistry design of integrated content and interdisciplinary curriculum for chemistry students: *Chemistry for life - integrated research*.

The scientific problem solved in the paper consists in theoretical and methodological demonstration through the functionality of the *Pedagogical Model of initial training of the professional competences of chemistry students in an interdisciplinary context* through the interdisciplinary curriculum: *Chemistry for life - integrated research*, focused on the initial training of future teachers' professional competences of and specialists in chemistry.

The results that contribute to solving an important scientific problem: *the Methodology for initial training of professional competences of the chemistry student in an interdisciplinary context* was developed, which allows the development of personality through research based on connections of disciplines related to Chemistry, which contributes to motivation for conscious and methodical training.

The theoretical significance of the investigation lies in the analysis, specification and establishing theoretical benchmarks produced by interdisciplinary ties on the initial training process of professional competences of future specialists in chemistry through the functionality of the Model, thus solving the problem of initial training of professional competences in chemistry in an interdisciplinary context at *Chemistry for Life - research integrated* course.

The applicative value of the research is argued by the establishment and demonstration of the theoretical-methodological benchmarks of training and development of professional competences through the functionality of the *Pedagogical Model of initial training of the professional competences of chemistry students in an interdisciplinary context* and implementation of the *Chemistry for Life - integrated research* training program within the curriculum, which contributes to initial training professional competences in chemistry in an interdisciplinary context.

The implementation of the scientific results: the developed methodology was used during the interdisciplinary course teaching *Chemistry for Life - integrated research*.

CODREANU SERGIU

INITIAL TRAINING METHODOLOGY OF THE PROFESSIONAL COMPETENCES OF THE CHEMISTRY STUDENT IN AN INTERDISCIPLINARY CONTEXT

532.02 SCHOOL DIDACTICS
(Chemistry)

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