Professional Training of Bachelors in Information Technologies based on Education for Sustainable Development Principles

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Abstract: The article examines the professional training of future bachelors in Information Technologies (IT) at universities in the context of the implementation of the Sustainable Development Goals set by the UN General Assembly, as well as the Education for Sustainable Development (ESD) principles. The UNESCO documents on education for sustainable development, scientific sources on the professional training of future IT specialists, as well as the integration of sustainable development into relevant educational programs are analyzed. The methodology and results of experimental work carried out intending to overcome existing contradictions, promoting sustainable development of information technology education and implementation of ESD principles in the process of professional training of future bachelors in IT are presented. In particular, the organizational and methodological conditions, that were implemented into the educational process, and experimental data are presented. The effectiveness of the experimental work was proved by statistical verification of the reliability of the obtained data.

1 INTRODUCTION

The achievement of the Sustainable Development Goals set in 2015 by the UN General Assembly (General Assembly, 2015) is linked to the training of highly qualified professionals from all sectors of the economy who are capable of reflection, professional mobility and lifelong learning, aware of the responsibility for the results of their activities. Such training is based on Education for Sustainable Development (ESD) principles.

According to UNESCO Roadmap "ESD empowers learners to take informed decisions and responsible actions for environmental integrity, economic viability and a just society, for present and future generations, while respecting cultural diversity. It is about lifelong learning, and is an integral part of quality education. ESD is holistic and transformational education which addresses learning content and outcomes, pedagogy and the learning environment. It achieves its purpose by transforming society" (UNESCO, 2014, p. 12).

Intensive development of information technology and the need to overcome the numerous challenges facing humanity, lead to an increase in requirements for professionals whose activities are creation, implementation and maintenance of software. The professional training of such specialists in the bachelor's and master's degrees in Ukraine is carried out in the specialities of the field of knowledge "Information Technology". To ensure that the level of professionalism of graduates of these specialities corresponds to the requirements of society, effective procedures of updating the content, forms, methods and means of training should be implemented based on systematic monitoring of the state of the industry and a balanced combination of fundamental, applied and humanitarian components of higher education.

An important area of professional work of IT specialists is the software development using an object-

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oriented approach, so graduates of higher education institutions should understand its fundamental principles, be able to use object-oriented programming (OOP) languages, to apply existing and make their own decisions, to decompose and compose tasks, to document the process of building an object model, etc. The lack of the necessary capabilities of the developers is one of the reasons for the low quality of software products, which in some cases pose a threat to the sustainable future. Other threats include a focus on current tasks and immediate goals, lack of understanding of global economic, environmental and social issues, opportunities to overcome or minimize them at the level of individual IT professionals or businesses, the impact of IT products on the present and future, and responsibility to future generations.

Scientists have thoroughly developed conceptual foundations and examined some aspects of higher education and professional training of future software engineers. However, insufficient attention is paid to developing their professional competence in the study of object-oriented programming, as well as to acquire the knowledge and skills necessary to pursue activities with a view to sustainable development goals. Therefore, there are contradictions between the need to combine the fundamental theoretical and thorough practical training of future software engineers as highly qualified specialists and the limited time of studying the disciplines of the vocational training cycle; the necessity of using abstraction, decomposition and composition in the process of studying OOP and insufficient level of abstract-logical thinking in students; high level of complexity of OOP educational content and insufficient readiness of higher education students to systematic cognitive self-activity; possibility to demonstrate the object-oriented approach on the example of large projects and traditional use of educational tasks with limited content; the society requirements for the professional training of software engineers and the students' lack of awareness of these requirements; lack of knowledge on sustainability issues and the need to promote a sustainable future in professional life and daily life (Koniukhov, 2019).

The other important issue is the formation of professional competencies of bachelors in Information Technologies in the conditions of a shortened cycle of professional training at universities. The contradictions that hinder the efficient formation of professional competences of future software engineers in the shortened cycle of training at universities have been identified, namely: between the requirements for the level of training of software engineers and insufficient motivation of higher education students to study and improve their skills; between the educational needs of higher education students and the limited ability to build individual educational trajectories and a combination of different forms of education, including non-formal one, at universities; between the availability of higher education students with professional competences formed during the previous level of education, and the content of educational programs for shortened cycle training of future software engineers at the bachelor's level at universities; between the need to comply with the provisions of the standards of higher education in Ukraine at the bachelor's level and the limited period of study in the educational programs for shortened cycle training of future software engineers at the bachelor's level at universities (Krasheninnik, 2020).

Therefore, there is a need to create at higher education institutions the conditions for students to develop appropriate professional competencies.

Purpose of the article: to present the results of experimental work carried out to overcome the mentioned contradictions and to promote sustainable development of IT education and implementation of ESD principles in the process of professional training of bachelors in Information Technologies.

2 LITERATURE REVIEW

As Mulà et al. (Mulà et al., 2017, p. 798) emphasis "The world is shaped by an education system that reinforces unsustainable thinking and practice". So, it is very important to transform an education system taking into account the aims of sustainability and sustainable future. Education for sustainable development principles is substantiated in numerous UNESCO documents (UNESCO, 2014, 2009, 2016; Tilbury and Mulà, 2009) and discussed in (Dlouhá et al., 2017; Lobanova et al., 2020; Mulà et al., 2017; Vlasenko et al., 2021).

Internationally recognized ESD principles are named by Tilbury and Mulà (Tilbury and Mulà, 2009). They are the next: Futures thinking; Critical and creative thinking; Participation and participatory learning; Partnerships; Systemic thinking (Tilbury and Mulà, 2009, p. 5). Moreover, there are pointed out key ESD learning themes (eg.: Gender equality; Biological diversity; Ecological principles, ecosystems; Natural resources management; Health and well-being; Consumerism and ethical trade; Rural and urban development; Corporate social responsibility) that are critically significant to the sustainable development agenda (Tilbury and Mulà, 2009, p. 6).

Providing quality education as one of the goals of sustainable development is an important area of modern pedagogical research. In particular, in 2020 the International Conference on Sustainable Futures: Environmental, Technological, Social and Economic Matters (ICSF 2020) was held, during which a workshop on sustainable education was held (Semerikov et al., 2020).

In particular, interesting results are presented in publications (Lavrov et al., 2020; Hevko et al., 2020; Glazunova et al., 2020), which consider ways to implement the problems of sustainable development in IT education.

Implementation of ESD principles in the process of professional training of bachelors in Information Technologies is in different ways, in particular: deep informatization of the educational process (Fedorenko et al., 2019); enhancing opportunities for professional mobility and lifelong learning for IT professionals through the development and implementation of intelligent means of recognition of qualifications and competencies obtained in different countries and educational institutions (Osadchyi et al., 2017); improving educational programs for the short cycle of vocational training (Osadchyi and Krasheninnik, 2017; Krasheninnik, 2020); improving the content, forms, methods and tools of object-oriented programming learning (Koniukhov, 2019; Koniukhov and Osadcha, 2020); introduction of sustainability issues to the content of educational programs (Penzenstadler and Fleischmann, 2011; Fisher et al., 2016; Cai, 2010; Hilty and Huber, 2018) and others.

Researchers in the field of professional training IT specialists note that sustainable development issues are hardly addressed in relevant university education programs. However, software developers should take their share of responsibility for sustainability because of the growth of IT's productivity in combination with cutting down of life cycles and growing resource problems of our planet (Penzenstadler and Fleischmann, 2011, p. 454). In this regard, it is necessary to determine the mechanisms for introducing sustainable development issues into university bachelors in Information Technologies curricula, as well as motivating students and teachers to address them.

Penzenstadler and Fleischmann (Penzenstadler and Fleischmann, 2011) offer a strategy for integrating the concept of sustainability into a degree course scheme across three stages: 1) to propose a seminar and form a core of interested people; 2) to give a lecture series for broadening the awareness for sustainability; 3) to establish sustainability as a topic by integrating it into the syllabus of appropriate software engineering lectures with teach-the-teacher seminars. During a seminar, students should examine chosen issue and present their topic in class. They are offered such seminar topics as "Climate killer Internet? Energy-efficient nets and systems have a notable impact", "Climate change research and software engineering for climate research", "Marketing for sustainability — how can I make it matter for software engineers?" etc. (Penzenstadler and Fleischmann, 2011, p. 455-456).

Fisher et al. (Fisher et al., 2016) emphasize the nexus between sustainability and computer science and the necessity to integrate sustainability science and engineering into computing education (Fisher et al., 2016, p. 95). They consider two levels of integration of sustainability into computer science higher education (the course level and the course component level) and give different examples of such combination. Scientists identify the course-level integration as introducing computer science courses that focus on topics at the intersection of computing and sustainability. These are such courses as "Computing, Energy, and the Environment", "Seminar on Computational Sustainability: Algorithms for Ecology and Conservation" etc. Component-level integration is implemented by introducing lectures, exercises, and projects, with sustainability themes into computer science courses that do not have a sustainability focus, such as courses in computer organization, databases, and artificial intelligence (Fisher et al., 2016, p. 93-94).

Three sustainability integration strategies are offered by Cai (Cai, 2010): 1) developing a new course named "green computing" covering selected sustainability and green computing topics; 2) designing and developing independent green computing learning modules and projects that can be easily plugged into the existing computer courses; 3) an integrative and transformative approach to completely re-design some computing courses with sustainability as one of the top priorities (Cai, 2010, p. 525-526).

Hilty and Huber (Hilty and Huber, 2018) consider that sustainable development is an important part of the curriculum of ICT-related study programs and content is strongly significant to interest students in it. They present results of an empirical investigation to identify topics with the greatest potential to motivate students on sustainability. Researchers reveal five clusters of such topics, namely: "ICT impacts on sustainability"; "Material resources for ICT hardware: Informal recycling"; "ICT as an enabler: Saving material and energy: Videoconferencing example"; "Resource consumption: Global distribution"; "Rebound effect: General concept" (Hilty and Huber, 2018, p. 652).

An example of IT students' participation in a project aimed solution one of sustainability tasks –

"provide safe, non violent, inclusive and effective learning environments for all" (General Assembly, 2015) – is given in (Kompaniets et al., 2019).

3 RESEARCH METHODOLOGY

3.1 Research Statement

The ideas of education for sustainable development were implemented in the process of research and experimental work on forming the professional competence of bachelors in Information Technologies.

The study consisted of two stages and covered 2015–2019. The main stage involved the professional training bachelors in the field of Information Technologies by the way of learning object-oriented programming. An additional stage was aimed formation of professional competencies of future IT specialists in the conditions of a shortened cycle.

The difference between the main and additional stages was the next:

1. The main stage was attended by students who studied in the terms of the standard period of study (4 years).
2. The additional stage was attended by students who studied for a reduced period of study (2 years). Most of them already had a professional education in the field of information technology at the level of a junior specialist.

We followed this sequence of pedagogical research:

1) comparison of the initial state of students' professional competence in the control and experimental groups according to certain criteria and indicators, establishing the absence of statistically significant differences;
2) introduction of the developed organizational and methodological conditions for the formation of professional competence of future IT specialists in the learning process in the experimental group;
3) comparison of the final state of students' professional competence in the control and experimental groups according to certain criteria and indicators, establishing the presence of statistically significant differences (Novikov, 2004, p. 10).

3.2 Main Stage Methodology

The main stage experiment was conducted during 2015–2018 at Ukrainian universities, in particular, Bogdan Khmelnytsky Melitopol State Pedagogical University. 135 computer science students have taken part in the qualifying and forming stages of the pedagogical experiment. The number of the control group (CG) was 69 people, experimental (EG) – 66 people.

In the course of this work, the levels of bachelors' professional competence components identified in (Koniukhov, 2019) were diagnosed:

- motivational: a set of motives that encourage higher education students to actively study OOP; their interest in the in-depth study and use of OOP in their further professional activities; readiness for self-development in object-oriented development;
- cognitive: development of abstract-logical thinking; possession of techniques of formalization, abstraction, decomposition and composition; understanding the fundamental basics of OOP and their implementation in different programming languages; set of theoretical knowledge of fundamental concepts and applied aspects of OOP;
- operational: skills in object-oriented programming necessary for effective professional activity;
- reflexive: the ability to self-understand, analyze and evaluate yourself as a specialist and your actions in the current situation, in the past and the future, as well as yourself as a member of the software development team.

Since the ECTS scale is used in the institutions of higher education of Ukraine to evaluate students' academic achievement, five levels of formation of these components of the professional competence of bachelors in Information Technologies have been identified:

- professional: certifies the formation of a component of professional competence at the level of an experienced software developer and the ability of the student to enter professional activity as a mid-level specialist without additional training, corresponds to the level "A" of the ECTS scale;
- high: certifies the formation of a component of professional competence at the level of a junior software developer and the ability of the student to start professional activity and independent tasks without additional training, corresponds to the level "B" of the ECTS scale;
- sufficient: certifies the formation of a component of professional competence at the level of the junior software developer and the ability of the student to start professional activity and independently perform tasks with additional training at the enterprise, corresponds to the level "C" of the ECTS scale;

- low: certifies the formation of a component of professional competence at the level of the novice programmer and the ability of the student to begin professional activity as a junior software developer only under the direct supervision and with additional training at the enterprise, corresponds to the level “D” of the ECTS scale;
- critical: certifies the extremely low level of professional competence component and the student’s lack of ability to take up professional work as a software developer, corresponds to the “E” level of the ECTS scale.

In the experimental group, the educational process was organized based on the following organizational and methodological conditions (Koniukhov, 2019):

1. Formation of positive motivation for students to study and apply in future professional activities of OOP. The implementation of this condition included a demonstration of examples of software development practice, meetings with leading specialists of IT enterprises, organization of group implementation of software projects, involvement of students in the discussion of practical aspects of the software engineering.
2. Formation of a cross-cutting content-activity line of studying OOP within the disciplines of the vocational training cycle. Within each successive course, fundamental concepts of object-oriented programming were repeated, and they were considered at a new level of complexity, taking into account the specifics of a particular area of software development.
3. Application of appropriate forms and methods of formation in higher professional qualifications. The implementation of this condition involved the implementation of various types of software projects, the use of training tasks in object-oriented programming, interactive teaching methods and game technologies.
4. Use of modern information and communication technologies in the process of education of students of OOP, namely: software for educational purposes, software development environments, visualization tools, training management systems, distance courses in academic disciplines and additional specialized online resources.

Some ESD ideas were implemented during the development of the students’ program projects. In particular, they were offered project topics such as developing programs for the statistical processing of observation data (demographic economic, meteorological, medical, biological, etc.); development of educational programs for students of general secondary education institutions (simulators, didactic games, etc.); development of programs for automation of separate production processes for enterprises of different industries, etc. To create quality software, students had to pre-analyze the problem given the problems of a sustainable future and the goals of sustainable development.

The measures envisaged by the pilot program were implemented within the training disciplines of the cycle of professional training: “Programming”, “Object-oriented programming”, “Cross-platform programming”, “Web application programming and support”.

To evaluate the likelihood of the experimental data obtained, a method of testing statistical hypotheses was used.

The hypothesis of the absence of significant differences in the average values of indicators of the formation of components of students’ professional competence in control and experimental groups was tested with Student’s t-test.

Volumes of control and experimental groups $n_{CG} = 69$ and $n_{EG} = 66$ respectively. Number of degrees of freedom $k = 133$. Critical significance of the Student test for 133 degrees of freedom and significance level $\alpha = 0.05$: $t_{cr} \approx 1.98$.

3.3 Additional Stage Methodology

The additional stage experiment was conducted during 2016–2019 at Ukrainian universities, in particular, Bogdan Khmelnitsky Melitopol State Pedagogical University. The research and experimental work involved examining problems and contradictions, identifying ways of overcoming them, implementing organizational and pedagogical conditions for the formation of professional competencies of future software developers in the shortened cycle of training, checking the effectiveness of the measures taken. A pedagogical experiment has been consisted of qualifying and forming stages. It was carried out at various stages among 405 Information Technologies students of the bachelor grade majoring in 121 Software Engineering, 122 Computer Science, 123 Computer Engineering, who studied based on the shortened training cycle. The control group included 207 students; the experimental group consisted of 198 students.

In the course of this work, the levels of professional competence components of future software developers identified in (Krasheninnik, 2020) were diagnosed:

- motivational: internal motivation for professional activity in the speciality of software developer, continuing education and training; at the stage of the pedagogical experiment the analysis was carried out separately by the criterion of internal motivation to continue education and advanced training and by the criterion of internal motivation to professional activity like a software developer;

- cognitive: complete acquisition of knowledge and understanding of the disciplines of the training cycle, the ability to formulate judgments based on available information and cognitive skills;
- operational: the ability to practical application of knowledge and skills in the professional activity, as well as to the effective organization of this activity;
- communicative: abilities for effective oral and written communication in groups with different composition of participants and goals of joint activities;
- reflexive: the ability to reflect on educational and production activities.

Five levels of formation of these components of the professional competence have been identified:

- high: the component is formed to a sufficient extent for the implementation of conscious educational and self-educational activities, as well as independent solution of professional problems in the field of software development on the middle level; corresponds to level “A” of academic achievements by the ECTS scale;
- sufficient: the component is formed to a sufficient extent for the implementation of conscious educational and self-educational activities, as well as independent (or with little help) performance of professional tasks as a junior software developer; corresponds to the level “B” of academic achievements by the ECTS scale;
- medium: the component is formed to a sufficient extent for the implementation of educational and self-educational activities, as well as the implementation of production tasks in the process of professional activity as a junior software engineer under management and with the help of experienced professionals; corresponds to the level “C” of academic achievements by the ECTS scale;
- critical: the component is formed at a level sufficient to perform certain types of educational activities and production tasks in the process of professional activity as a junior software engineer under the direct guidance and control of teachers or experienced professionals; corresponds to level “D” of academic achievements according to the ECTS scale;
- low: the component is formed at a level insufficient for effective educational and professional activities in the speciality of software engineer; corresponds to the level “E” (satisfactory success) or “F” / “FX” (unsatisfactory success) of academic achievements on the ECTS scale.

In the experimental group, the educational process was organized based on the following organizational and methodological conditions (Krasheninnik, 2020):

- formation of stable positive internal motivation to higher education, professional activity, advanced training;
- systematic review and updating of educational programs for shortened cycle training of future software developers at the bachelor’s level, taking into account current trends in the field of information technology and higher education;
- providing future software developers opportunities for individual educational trajectories under the conditions of the shortened cycle of professional training at universities;
- application of expedient forms, methods and means of formation of professional competencies of future software developers under the conditions of the shortened cycle of professional training at universities.

The probability of the results obtained at the qualifying and formative stages of the experiment has been checked using the Fisher test in combination with the Kolmogorov-Smirnov test.

4 RESEARCH RESULTS

4.1 Qualifying Stage

The empirical data obtained at the qualifying stage of the pedagogical experiment gave reason to draw the following main conclusions:

1) students in the control and experimental groups found an insufficient level of professional competence development: approximately one-third to two-thirds of them demonstrated low or critical level of professional competence;
2) the initial level of professional competence in both groups practically did not differ (the difference between the percentage of students at each level of education in terms of individual competence components did not exceed 3%), which testified to their homogeneity.

According to the results of estimation of the motivational component of professional competence, 34.78% of students (24 persons) of CG and 34.85% of students (23 persons) of EG revealed low or critical level. At the same time, 46.38% of students (32 persons) of CG and 45.45% of students (30 persons) of EG showed sufficient level. So, at the end of their first year, they understood the need for knowledge of object-oriented programming technologies and languages and were partially motivated to further study OOP.

According to the results of the assessment of the cognitive component of professional competence, 68.12% of students (47 persons) of CG and 68.18% of students (45 persons) of EG have found low or critical level. This situation is to a certain extent because the first year focuses on the study of algorithmization, structural and procedural programming, and the mechanisms of OOP are mostly considered indirectly to the extent necessary for writing programs in development environments.

According to the results of estimation of the operational component of professional competence, 75.36% of students (52 persons) of CG and 71.21% of students (47 persons) of EG revealed low or critical level. The reason for this is that at the end of the first year students have initial experience writing programs with classes and objects, but they do not yet use the full-scale OOP mechanisms.

As a result of assessing the reflexive component of the professional competence, 47.83% of students (33 persons) of CG and 48.48% of students (32 persons) of EG revealed low or critical levels. At the same time, 37.68% of students (26 persons) of CG and 34.85% of students (23 persons) of EG showed sufficient level, which testified to the partial formation of the ability to evaluate themselves as a student, member of academic group and software development team, as well as the results of its activities.

Valuation of the obtained data. The hypothesis about the absence of statistically significant differences in the average values of indicators of the formation of the components of students' professional competence in the control and experimental groups was performed using the Student's t-test.

The null hypothesis: there is no statistically significant difference between the samples, the average values of the indicators of the professional competence components of the students of the control and experimental groups are equal.

Alternative hypothesis: there is a statistically significant difference between the samples. the average values of indicators of the formation of components of professional competence of students in the control and experimental groups differ significantly.

The results of testing these statistical hypotheses are given in table 1.

Table 1: Results of valuation of the obtained data (qualifying stage of the experiment).

Components of professional competence	t_{emp}	Conclusion
motivational	0.47	$t_{emp} < t_{cr}$
cognitive	0.33	$t_{emp} < t_{cr}$
operational	0.12	$t_{emp} < t_{cr}$
reflexive	0.01	$t_{emp} < t_{cr}$

Thus, it is proved that there is no statistically significant difference in the levels of the professional competence components between students of the control and experimental groups at the qualifying stage of the pedagogical experiment, that is, the samples are homogeneous.

Based on the analysis of empirical data of the qualifying stage of the pedagogical experiment, it was concluded that the level of the professional competence of future software engineers was generally low and critical.

To increase this level, the study of object-oriented programming had to be organized in such a way as to ensure the acquisition and completeness of students' acquisition of basic and special knowledge of OOP (cognitive component), the effective formation of their OOP skills and ability to use them to develop software projects (operational component), persistent high motivation to study OOP, its further use in professional activity, and self-improvement in this field (motivational component), formation of the ability to evaluate and responsible attitude to the results of their work and role in the team (reflexive component).

4.2 Forming Stage

The empirical data obtained during the formative stage of the pedagogical experiment gave reason to make the following generalizations:

1) the overall level of students' professional competence has increased: in both groups the increase in the number of students at the professional and high levels, as well as the increase in the average values of the indicators of the components of professional competence, but the changes in the experimental group were more significant;
2) the final levels of the components of students' professional competence in the experimental group exceeded the corresponding indicators in the control group.

Based on these data, a preliminary conclusion was made about the effectiveness of implementing the organizational and methodological conditions for forming the professional competence of bachelors in Information Technologies in the process of studying object-oriented programming.

The results of the assessment of the motivational component of professional competence revealed that in the experimental group the percentage of students with professional and high level was equal to 21.21% (14 people) and 42.42% (28 people) respectively. In the control group, there were minor changes and this indicator was 10.14% (7 persons) and 18.84% (13 persons), respectively. A significant difference was observed in the indicators characterizing the number of students with low and critical levels: 6.06% (4 persons) and 3.03% (2 persons) in EG; 15.94% (11 persons) and 5.80% (4 persons) in CG respectively (figure 1).

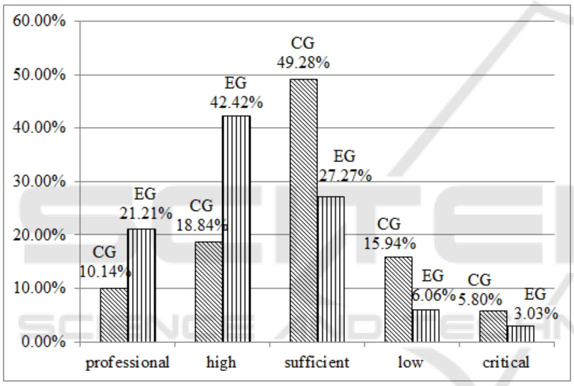

Figure 1: Formation of the motivational component of students' professional competence (forming stage of the experiment).

According to the results of the assessment of the cognitive component of students' professional competence, it was found that in the experimental group the percentage of students with professional and high level became equal to 21.21% (14 persons) and 36.36% (24 persons), respectively. In the control group, there were slight changes and this indicator was 4.35% (3 persons) and 11.59% (8 persons) respectively. A significant difference was observed in the indicators characterizing the number of students with low and critical levels: 9.09% (6 persons) and 3.03% (2 persons) in EG; 28.99% (20 people) and 8.70% (6 people) in CG (figure 2).

According to the results of the evaluation of the operational component of students' professional competence, it was found that in the experimental group the percentage of students with professional and high level was equal to 19.70% (13 persons) and 40.91%

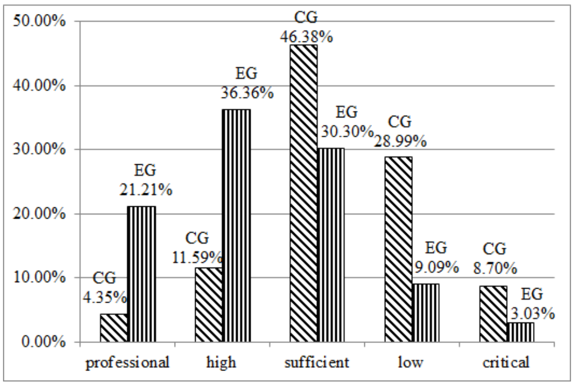

Figure 2: Formation of the cognitive component of students' professional competence (forming stage of the experiment).

(27 persons), respectively. In the control group, there were slight changes and this figure was 5.80% (4 persons) and 15.94% (11 persons), respectively. A significant difference was observed in the indicators characterizing the number of students with low and critical levels: 9.09% (6 persons) and 3.03% (2 persons) in EG; 31.88% (22 persons) and 13.04% (9 persons) in CG, respectively (figure 3).

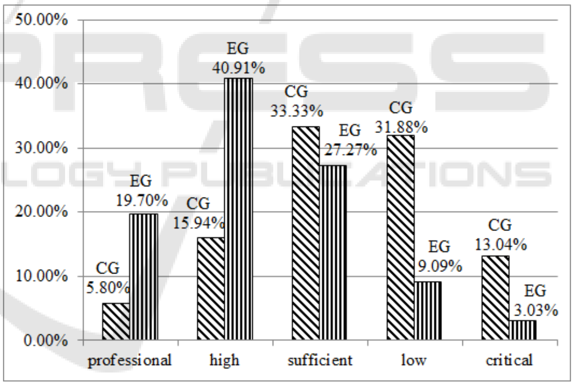

Figure 3: Formation of the operational component of students' professional competence (forming stage of the experiment).

According to the results of the evaluation of the reflexive component of students' professional competence, it was found that in the experimental group the percentage of students with professional and high level was equal to 22.73% (15 people) and 30.30% (20 people), respectively. In the control group, there were slight changes and this indicator was 10.14% (7 people) and 15.94% (11 people), respectively. A significant difference was observed in the indicators characterizing the number of students with low and critical levels: 6.06% (4 persons) and 3.03% (2 persons) in EG; 23.19% (16 people) and 8.70% (6 people) in CG, respectively (figure 4).

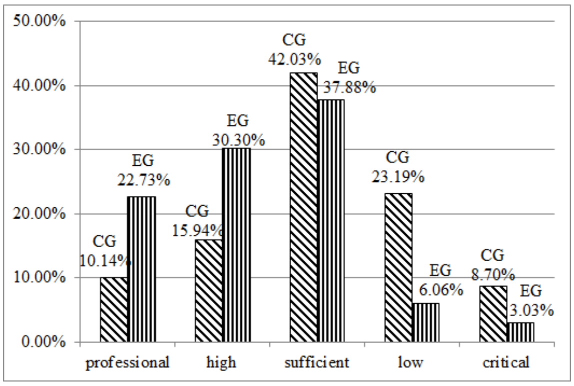

Figure 4: Formation of the reflexive component of students' professional competence (forming stage of the experiment).

Valuation of the obtained data. Testing of the hypothesis about the statistically significant differences in the average values of the formation of components of students' professional competence in control and experimental groups, and therefore different levels of formation of professional competence was generally performed using the Student's t-test.

The null hypothesis: there is no statistically significant difference between the samples, the average values of the indicators of the professional competence components of the students of the control and experimental groups are equal.

Alternative hypothesis: there is a statistically significant difference between the samples. the average values of indicators of the formation of components of professional competence of students in the control and experimental groups differ significantly.

The results of testing these statistical hypotheses are given in table 2.

Table 2: Results of valuation of the obtained data (forming stage of the experiment).

Components of professional competence	t_{emp}	Conclusion
motivational	2.85	$t_{emp} > t_{cr}$
cognitive	6.09	$t_{emp} > t_{cr}$
operational	5.32	$t_{emp} > t_{cr}$
reflexive	2.87	$t_{emp} > t_{cr}$

Thus, the statistically significant differences in the levels of components of students' professional competence in control and experimental groups at the formative stage of the pedagogical experiment were proved. So, we can conclude that the average difference is not accidental, but is the result of the implementation of the proposed organizational and methodological conditions for the formation of professional competence of bachelors in Information Technologies in the process of studying object-oriented programming.

4.3 Additional Stage

At this stage of research, the survey method was used, the content of the disciplines of the cycle of professional training of bachelors in Information Technologies was updated taking into account the goals of sustainable development, the implementation of educational projects was organized. The survey was conducted using a modified Olsson questionnaire (Olsson, 2018).

At the formative stage of the experiment, positive changes at the levels of formation of the components of professional competencies of future software engineers have been recorded. In the experimental group, these changes have been more pronounced and at the end of the experiment, there have been significant differences between the control and experimental groups. The share of participants in the experiment with a sufficient and high level of formation of the motivational component of professional competencies (the criterion of formation of internal motivation to continue education and training) in the control group has increased by 12.08%, in the experimental group it has increased by 26.76%; the motivational component (the criterion of formation of internal motivation for professional activity of a software engineer) has increased by 13.52% and 26.77%, respectively; the cognitive component has increased by 5.80% and 19.70%, respectively; the operational component has increased by 10.63% and 23.23%, respectively; the communicative component has increased by 4.83% and 23.23%, respectively; the reflexive component has increased by 15.46% and 28.78%, respectively.

5 FURTHER RESEARCH

Research conducted in 2015–2019 has shown that the introduction of sustainable development issues into the content of curricula influenced positively the quality of training for IT specialists at universities. Of greatest importance is the incorporation of students' educational and scientific projects, when they have the opportunity to get acquainted with the problems of sustainability and the sustainable development goals (SDG) as well as to offer ways of solving them, in particular, through the development of specialized software.

Therefore, at the end of the experiment, it was decided to continue the work on integrating the content of IT education in Bogdan Khmelnytsky Melitopol State Pedagogical University with sustainability issues. We followed the recommendations outlined in (Fisher et al., 2016; Cai, 2010; Hilty and Huber, 2018). In 2020, individual conversations were held with educators of the Department of Informatics and Cybernetics to determine the most promising approaches to achieve this goal. As a result, it was found that component-level integration and course-level integration (according to Fisher et al. (Fisher et al., 2016) classification) are the most expedient.

The first approach is the simplest to implement since it only involves updating the content of training courses and introducing additional topics or modules, as well as changing the types of training activities. Such work has already been partially carried out during the 2015–2019 experiment as part of the training of bachelors in Information Technologies. Therefore, at the next stage, changes were made in the content of the master's training courses, as well as in the topic of diploma projects. Besides, engaging students in the research funded by a grant from the Ministry of Education and Science of Ukraine (No. 0120U101970) to achieve SDG 4 "Quality Education" also helps raise their awareness of sustainability issues.

The second approach was decided to be implemented by introducing new disciplines of students free choice, the content of which is fully devoted to the problems of sustainability. This direction presupposes the formation of completely new content, therefore such courses are now at the development stage.

6 CONCLUSION

The transformation of society to meet the goals of sustainable development is impossible without the active participation of each citizen. Training for such activities should be undertaken at educational institutions of all levels based on Education for Sustainable Development principles.

The realization of the goals of education for sustainable development in the process of professional training of bachelors in Information Technologies implies deep informatization of the educational process, enhancement of opportunities for professional mobility and lifelong learning, improvement of educational programs, the introduction of issues of sustainability and content.

In the process of experimental work, attention was paid to acquaint students with the goals and objectives of sustainable development. We believe that it is advisable to direct further research on the implementation of disciplines and individual modules aimed at familiarizing students with the problems of a sustainable future and understanding of their role in solving these problems in IT curricula.

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