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Efficiency of Integration of Knowledge, Forms and Methods of Education of Students in Vocational-Technical School

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Abstract

The article demonstrates the expediency of integrating of knowledge of the structure and properties of substance and building materials. It is shown that this approach avoids duplication of related material, overcomes inconsistency in the interpretation of concepts, the use of quantities and units of their measurements. Didactic requirements for the implementation of the ideas of integrated learning of related material are substantiated, the integrated content of knowledge of the substance and materials is worked out, different forms and methods of knowledge integration are tested depending on the nature of the integrated material. Special feedback from teachers of special technology and masters of industrial training is received. The training offered by our programs also receives a positive assessment of the students due to the decrease in the workload, the reduction of homework with the same educational significance, the availability of special concepts, the emergence of interest in the study of physics. The experiment reveals that integrated lessons, lectures, laboratory and tests, as well as integrated questions, tasks with integrated content, concretization and supplementation of physical knowledge with general and special ones, use of complex tasks, etc. are found to be effective forms of knowledge integration. Generalization of the results of the experimental work shows the benefits of learning oriented programs that involve the integration of students' knowledge about the structure and properties of substance and building materials. It is important not to overburden any educational process with excessive integration, but to focus on its optimal use: in fact, the laws of educational integrology are aimed at it.

Key words: *integration, integration in education, integration of knowledge, integration of forms and methods, training, students, vocational school*

Introduction

Scientific understanding of integration processes that are actively developing in the society in the second half of the XX – beginning of the XXI century affect the education. It resulted in fast growing number of researchers on the topic given at the general scientific level, as well as in the educational aspect: integration in enhancing teaching and learning (B. Bandhana, 2012), the curriculum integration (J. Beane, 1998), integrated education (M. Fan, 2004), obstacles to integration in education (W. Pelgrum, 2001), effects of technology on education integration (C. Rhonda, 2002; S. Rodney, 2002), teaching and learning of the integrated science (A. Jacinta, 2011), predictors of technology integration in education (K. Rogers, J. Wallace, 2011) etc.

We are convinced that the problem of integration in education should be solved not only at the empirical level but on the basis of a profound theoretical-methodological and philosophical bases. Many authors dedicated their publications to this area: integration of theoretical and practical undergraduate training in the processes of developing student teachers' professional competences (Rovnanova L. & Nemcova L., 2017), the integration of instructional technology into public education (Rodney S., 2002), form of curricular program integration (Udom, P., 2005), needs for the integration of agricultural subject with Thai Language (Satiansiriwiwat, S., Intorrathed, S., & Siriwan, S. 2016) etc.

At the same time, many problems related to the development of a holistic theory of the integration in education still need special research. These difficulties include the cumbersome disordered terminological apparatus of integration; lack of coordination of approaches to understand integrative approaches in education; divergence of scientific research on various aspects of the problem; the presence of a large number of separate principles, regulations, and laws related to integration; fusion of the concept of "integration" at numerous levels, scales etc.; identification of integration with similar concepts (synthesis, complexity, systematization, interdisciplinary) and the replacement of integrative processes with eclectic ones, etc.

Thus, in the practice of vocational educational institutions, the combination of curricula of secondary schools and vocational schools has led to increased consumption of study time, reducing the quality of general knowledge of VES students, duplication of educational material in different courses of subjects, knowledge disunity, and the unjustified overloading of knowledge.

We believe that the effective way of eliminating these shortcomings is the introduction of integrative forms and methods of teaching in the educational process, and the integration of the content of students' knowledge. It promotes the formation of a comprehensive system of knowledge of students, activates their mental activity, enhances the educational functions of education. As a result, both the quality of students' general education knowledge and the level of their professional training increase. The importance of the problem of knowledge integration is also significant because at this stage, it is necessary not only to use natural resources rationally, but also to create new materials and technologies.

Many researchers agree that knowledge integration in vocational training is important as it is the knowledge itself that provides a solid foundation for the development of key competences. There is a growing body of research focusing on both theoretical and practical aspects of the issue: integrated education (M. Fan, 2004), obstacles to integration in education (W. Pelgrum, 2001), predictors of technology integration in education (K. Rogers, J. Wallace, 2011), etc.

However, there is limited evidence of multidimensional analysis of staged influence of knowledge and skills and their integration on students' competence. It would also be of importance to consider vocational competences expressed through such specific aspects as efficiency, diligence, speed of assimilation, purpose, etc.

The object of research refers to aspects of integration of knowledge and skills as means of improving levels of students' professional competence. The aim of research is to establish the relationship between the quality of acquired knowledge, skills and professional competences and the level of knowledge integration following the proposed methodology. The objective of the research is to compare the qualitative and quantitative aspects of knowledge and skills integration following the traditional and proposed methodology with the influence this integration may have on students' skills and professional competences.

Research Methodology

The prognostic function of integration is the transition of its status from an instrument to a scientific methodology that is able to solve a number of debating issues in specific educational problems. From our point of view, what is most relevant is that integration (as a means of transitioning a set of elements into a new quality) is based on the resurgence of natural, objectively existing links between the elements. The development, as a process of emergence of new qualities that are significantly different from previous ones, is one of the most essential features of integration. Laws, dynamic and statistical patterns, the likelihood of events and processes occurring in different systems under an integrative approach are considered interdisciplinary. A number of phenomena that are seen as an opportunity in one area of knowledge become reality in another one. During the integration, the external and internal status can change, giving a more complete picture of the phenomenon or object under study. The essence and the phenomenon of the integrative approach are the most complete, and also eliminate the danger of changing the essence of visibility. Therefore, we emphasize that the integrative approach fulfills its methodological function only if its use is justified.

Methods

Data was collected with the use of a survey and analysis was carried out using descriptive statistics methods. The comparison between control and experimental groups was made using Student's criterion t-test independent by groups (quantitative data) and criterion Pearson test (nominal data) with the view of establishing the effectiveness of applying an integrative approach to the formation of students' professional competences.

The basis of the empirical research and its sample

The survey was conducted with students of the specialty "Vocational Education (Computer Technologies)" in Interregional Vocational School of Road Transport and Construction and specialty "IT Education" in State Educational Institution "Higher Vocational School" № 8 in Stryi. The experimental group was taught using the integrative approach. Following the results of written tests and work experience, the students were assessed with the use of the following categories: professional knowledge (quantitative 100-point scale), professional skills (qualitative scale: low, Average, high) and professional competence (qualitative scale: absent, partially present, present). The group comprised 214 students.

Research Results

The summary of the results of research and experimental work shows the advantages of learning in targeted programs, which involve the integration of students' knowledge about the structure and properties of substances and building materials. The introduction of integrative forms and methods in the educational process helps to increase students' knowledge of physics, materials science and specialized disciplines.

The effectiveness of the implementation of knowledge integration is tested at three levels. At the first level, only some topics and sections of the program are tested, or the integration of knowledge only in terms of content. At the second level, the effectiveness of the integration of the content and forms of education are tested simultaneously, concerning all topics of the Physics course related to the structure, properties of substances and building materials. The third, the highest level, combines the integration of the content of educational material, the use of integrative forms of learning, and also provides for the synchronization of educational material in physics and materials science. At this level, synchronization causes the greatest organizational difficulties.

A total number of the students involved in the experiment is 25.

The comparison of results in control and experimental groups leads to the conclusion that the experimental groups observed qualitative changes in students' knowledge. When answering the questions, the students of experimental groups try to proceed from the essence of the physical phenomenon that underlies the properties of the substance process. The understanding of physical nature of the learning material allows them to apply effectively physical and material science knowledge in specialized technology and vocational training: the knowledge levels of students of experimental groups in specialized technology were higher than those of the control groups.

In explaining the properties of materials and studying technological operations, the students of the experimental groups tried to explain the physical essence of the phenomenon, to apply different knowledge (in physics, chemistry, materials science). The phenomenon or process was considered not only as purely technical by the students of the experimental groups but in all their complexity

An important result of the integration of students' knowledge was that students of the experimental groups not only had a system of interconnected concepts and could use them effectively, but they also developed the need to penetrate into the nature of the phenomenon, to compare the results of different approaches to the phenomenon, to consider it comprehensively. At the lessons of physics, students applied knowledge of materials science and vice versa. Let us show the confirmation of these findings in specific examples.

1. The students of the control and experimental groups were asked to compare the properties and briefly describe the crystalline and amphorae bodies. In the answers of the students of the control groups, at the lessons of physics, there were practically no specific examples of different states of bodies, and at the lessons of material science the answers contained only isolated facts, not only related to the physical bases of this knowledge but also to each other.

The students of the experimental groups gave the answers both at the lessons of physics and materials science, trying to build them in a certain sequence with the use of physical and material science. First of all, the students tried to tell about the peculiarities of crystalline bodies: the presence crystal lattice, elementary cells, types of crystal lattice. Some answers suggested that each type of chemical bond corresponds to a specific type of a crystal lattice. The students also tried to explain the difference between ideal and real crystals.

2. Analyzing the answers to the questions of integrative character, it can be noted that the students of the experimental and control groups answered the questions of the first subgroup in a different way, which envisaged the basic knowledge in physics. For example, almost all the students in the experimental groups were able to answer and substantiate their answer to the question "Does the density of bodies change when it is heated?". In the control groups this question turned out to be quite difficult for most students. The largest difference in responses was observed in the third subgroup of questions of a production nature, where the level of knowledge of the students in the experimental groups was significantly higher, which indicates the direct impact of integration of general education and general technical knowledge on the level of professional knowledge.
3. At the end of the courses of physics and materials science the students of the experimental groups solve the tasks much faster, more accurately and more qualitatively. The analysis of the control work on Molecular Physics and Thermodynamics showed that the majority of the students of the experimental groups coped with the tasks of integrative nature, and their solution was often more rational and justified than the solution of the students of the control groups. The combined problem of mechanical properties of materials and thermal expansion was solved by the majority of students in the experimental groups, but caused difficulties for the students of the control groups. The same picture is observed when solving quality tasks.

The most effective forms of knowledge integration were integrated lessons, lectures, laboratory and test work. Such methods of knowledge integration as storytelling, integrated questions, tasks with integrated content, concretization and supplementation of physical knowledge both with general technical and special one, the use of complex tasks, gave positive results.

The results of a survey of teachers of physics and materials science, as well as conversations with teachers of special technology and masters of vocational training made it possible to conclude that they generally accept the proposed plans and programs for the study of physics and materials science. First of all, because it increases the motivation to study physics and the level of knowledge of students in all three subjects. The learning offered by our programs has also received a positive assessment of the students. Most of them explain it by decreasing the load, reducing the volume of homework at the same pedagogical value, the availability of the study of special concepts, the emergence of interest in the study of physics.

We briefly present the results of quantitative analysis of students' knowledge in the integration of content and forms of learning. To determine the effectiveness of learning according to the proposed programs and the of use integrative forms of learning, the coefficients of mastering the relevant qualitative ($K_{\tilde{y}}$) and quantitative ($K_{\hat{e}}$) knowledge of students are calculated:

$$K_{\tilde{y}} = \frac{A}{Q}$$

where: *A* – the number of correct answers to questions;
Q – the number of questions asked

$$K_{\hat{e}} = \frac{R}{N}$$

where: *R* is the number of correctly performed actions;
N is the number of actions that must be performed to obtain the correct answer.

Accordingly, the levels of students' knowledge were set on the following scale:
Level 1 Grade "5" 1< K <0.9
Level 2 "4" 0.9 < K < 0.7
Level 3 "3" 0.7 < K < 0.5
Level 4 "2" 0.5 < K < 0.3
Level 5 "1" K < 0.3
The results of the analysis are presented in table 1.

Table 1. Coefficients of students 'knowledge acquisition at different levels

Levels Knowledge	Mastering Coefficients (in percent)	
	Ascertaining groups	Experimental groups
1	8	28
2	32	48
3	48	20
4	8	4
5	4	-

As can be seen from Table 1, training in experimental programs helped to increase higher and intermediate levels of knowledge and reduced the number of students with weak and very weak levels of knowledge.

Analyzing the level of students' awareness of the acquired knowledge, we used a five-level system, where the levels are arranged in order of importance. The results of the analysis are presented in table 2. As it can be seen from the table, the coefficient of knowledge acquisition for different levels in students of experimental groups is much higher for didactically important levels that involve students' ability to creatively use knowledge. This is directly facilitated by their integration. Levels of knowledge were set on the following scale:

1– fragmentary knowledge
2 – formal knowledge
3 – awareness of the perception of factual material
4 – application of knowledge in familiar situations
5 – application of knowledge in non-standard situations

Table 2. Level of awareness of knowledge

Level	Assimilation coefficients (in percent)		
	Ascertaining groups	Control groups	Experimental groups
1	40,3	41,6	11,7
2	29,2	29,7	4,8
3	16,5	16,0	10,5
4	12,8	12,2	43,2
5	1,2	1,1	29,8

An important indicator of the level and quality of students' knowledge is their thoroughness, which can be roughly estimated using the coefficient of soundness of knowledge

$$\mathrm{T} = \frac{C}{M}$$

where: C – knowledge / in the form of elements: concepts and operations /
M – knowledge that remains in memory / active / for time T after their receipt.

The results of the analysis of the soundness of knowledge are presented in table 3.

Table 3. Coefficients of soundness of knowledge

Time interview	Coefficient of soundness of knowledge (in percent)	
	Control groups	Experimental groups
0	82	82
1 week	81	82
2 weeks	78	81
1 month	75	80
3 months	62	76
6 month	42	70
1 year	24	70

Pearson's criterion was used to test the validity of the obtained results (the differences between characteristics were compared with a reliable boundary, which expresses the boundaries of random variations (if the difference is greater than the reliable boundary, then the difference is significant, it expresses the systematic difference of the compared characteristics).

The test began with the formulation of the null hypothesis: the sample data were obtained from statistically identical populations, and therefore any difference in students' knowledge levels at the beginning and end of the experiment was a random variation. In the second step, the theoretical frequencies were calculated (see Table 4). The third step of the calculation was to determine the differences between the respective observed and theoretical frequencies. In the fourth step, a comprehensive indicator χ^2 was calculated. A probability corresponding to this value was then determined (= 0.05, a reliable probability of 0.95). The fifth – the last step – was to search an upper bound χ_0^2 for χ^2 and compare them. According to $\chi_0^2 > \chi^2$ the null hypothesis was denied, and therefore it was argued that the difference between the groups is systematic, that is, caused by the implementation of the proposed methodology.

Table 4. Computation of a Complex Indicator χ^2

Group	Educational Activities			
	Volume	Level		
		Low	Average	High
At the beginning	25	76	98	22
At the end	25	62	86	48
Total	50	138	184	70

	Theoretical Frequencies			
At the beginning	25	69	92	35
At the end	25	69	92	35
Total	50	138	184	70
	Frequency Differences			
At the beginning	0	-7	-6	13
At the end	0	7	6	-13
Total	0	0	0	0

Thus, in the course of research and experimental work the pedagogical expediency of integration of knowledge about the structure and properties of substances and building materials is proved; it is shown that it makes it possible to avoid duplication of related material, to overcome inconsistencies in the interpretation of concepts, the use of quantities and units of measurement. Didactic requirements for the implementation of the ideas of integrated learning of related material are substantiated, the integrated content of knowledge about matter and materials and the principles of thematic planning of physics and materials science courses by future machinists of construction machines are worked out, different forms and methods of knowledge integration.

The testing showed that the redistribution of students by level of knowledge had undergone significant changes compared to the initial testing (see Fig. 1):

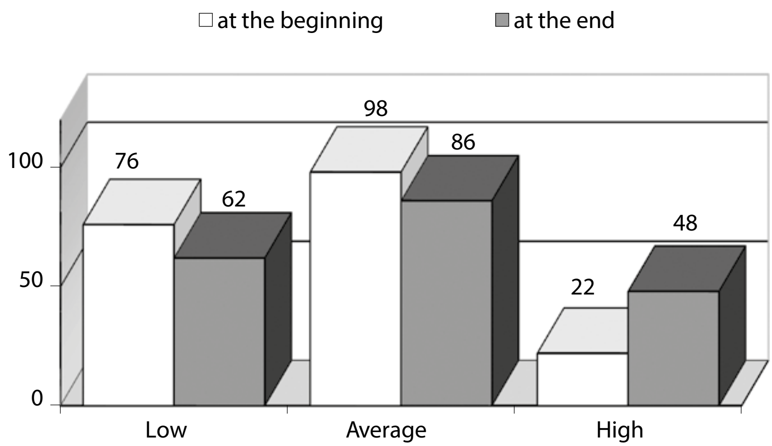

Figure 1. Students distribution chart according to the level of knowledge at the beginning and the end of the experiment (according to the number of students)

Conclusion & discussion

The integration of students' knowledge is an effective, sometimes non-alternative tool for shaping students' scientific outlook.

The integration of general and technical knowledge on a scientific basis is a reliable basis for the formation of vocational knowledge; this ensures the effectiveness of knowledge, its depth, completeness, accessibility etc.

The integration of knowledge makes it possible to eliminate such negative phenomena as duplication of knowledge, the overload of students, fragmentation and formalism of knowledge, since it implies a unified approach to knowledge, their systematicity and interaction.

Integration of knowledge allows to provide logic of formation of complex concepts, understanding by students of physical essence of the phenomena which are studied in various subjects, correct and creative application of knowledge in the future professional activity of students.

Knowledge integration and forms of knowledge integration in the educational process must be scientifically substantiated in order to avoid pseudo-integration and eclecticism in the teaching material.

Knowledge integration has been appropriately implemented at various levels (knowledge proficiency, inter-curricular links, knowledge synthesis, knowledge interaction, etc.) and in various forms. The integration of knowledge in the educational process, in contrast to the synthesis of knowledge, involves the differentiation of knowledge. The processes of integration and differentiation, as well as the correlation between subject and integrated learning, depend on the content of specific subjects and profiles of vocational schools.

The implementation of integration into the educational process requires a certain sequence and involves such stages of research as the analysis of programs in disciplines that form complex concepts, the establishment of the structure of the integrated educational material (the selection of concepts, the definition of objective prerequisites for their integration, the establishment of a logical sequence of study educational material, the substantiation of forms and methods of knowledge integration); the analysis of the acquired knowledge system as a whole, the identification of qualitative and quantitative changes related to the integration implementation process.

Many problems related to the development of a holistic theory of integration in education still need some research. This led to the justification of a new field – educational integrology. We are convinced that a holistic theory of educational integration should be shaped as a scientific theory (regardless the field of research) – that is, based on a system of laws (or regularities, postulates) and their consequences that explain a large number of empirical facts and have predictive capabilities. This is a positive role for educational integration laws for the transition from an axiomatic to a rigorous scientific theory of educational integration, for explaining a large number of empirical facts and observations based on educational integration laws and their consequences, and for strengthening the prognostic component of the scientific foundations of the educational field.

Discussions include issues that are directly related to integration in the educational field. It is important not to overburden any educational process with the excessive integration, but to focus on its optimum use: in fact, the laws of educational integrology are aimed at it. A number of problems are created by the presence of false integration, covering-up by the term integration of processes that are not integrative in the scientific sense.

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