A systematic approach to the formation of general professional competencies during the specialists' training in the field of aquaculture

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Abstract. Basing on the assumption that the basic foundations of the natural science knowledge which should be developed in the process of mastering the disciplines of the educational program should be laid for the successful formation of General professional and universal competencies of future specialists in the field of aquaculture, the research goal was chosen: to study the degree of formation of the natural science knowledge among students of the specialty "Water bioresources and aquaculture". In the written survey took part future specialists in the field of aquaculture of the first year of study (N0=60) and fourth-year students (N1=38).For statistical assessment of the results were used Fisher's φ-test and Student's t-test ($p \leq 0.01$).The results showed that there were no significant differences between basic knowledge in the field of natural Sciences for the 1st-yaer and 4th-year students. The significant differences were identified in students' definition of the difference between natural science and parascientific fields of knowledge, but the best result was shown by 1st-year students. It can be concluded that pedagogical technologies used for the formation of General professional and universal competencies need to be modernized, and further research and development of new methodological approaches to teaching disciplines related to basic natural science knowledge will be promising.

1 Introduction

Digital economy dictates new requirements for the rates of learning of information and for quality of its processing by specialists.

The transition to competence approach in high professional education highlighted the problem of competence formation methodology and the problem of assessment of its formation. In particular training of specialists in aquaculture area supposes them to be in possession of a large number of information in digital technology's area, which are based on fundamental natural science provision.

The issue of forming «key competences» which was raised in 1996 in Bern under the CE's (Council of Europe) programme assumed indissoluble connection of education and activities of the individual in everyday life. The opportunity to realize family life successfully, to reach professional skills, to behave like competent society member assumed an initially inherent ability to analyze the information and to verify it as acceptable for the

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basis of their activities and unacceptable, scientific and unscientific. In educational standards 3++ which are applied nowadays this ability is not mentioned. It can be suggested that it is supposed to achieve the formation of complex natural science knowledge during the secondary education's process. However, the rate of accumulation of information in science field is increasing every year. The concepts of approach to education as to an accessible, widespread, acceptable and adaptable socialization way were suggested by Katarina Tomashewski, UNO's (United Nations Organization) special rapporteur on the right to education. The most significant educational feature should become an opportunity to adapt educational methods to implementation in the basis of the educating course the information which constantly expands the scope of longstanding natural science knowledge. It is also very important to assess complicated situations occurring by realization of educational programs and choose right methods for its overcoming and preventing. In order to complete this it is necessary to use basic science premise as a defining activity vector. The mastering of common competencies in the current formulation is not enough for this type of activity.

In case when universal competencies are not «universal» enough for technical and science areas of professional education, an elaborate approach to the formation and implementation of general professional competencies may help for compensation of knowledge gaps. It is required a specific set of views which can be incorporated into a structure of educational programs of general professional competencies to develop professional skills in a wide range of areas, including future specialists in aquaculture.

It is necessary to form systematic natural science knowledge to train a specialist in the fields of exact and natural sciences. This involves knowledge of the basic laws of exact and natural sciences, possession of the basics of the scientific knowledge's methodology, the ability to be critical of generally accepted truths and information in mass communication and advertising. Let us trace the system approach to this task in Federal State Standard on specialty 35.03.08 Aquatic bioresources and aquaculture. Universal competence (UC) 1 supposes that student can search for information, critical analyze and synthesize it, use the system approach for the tasks' completing. In the list of General Professional Competencies (GPC), 1 competence implies the ability of a student to complete typical tasks of professional activity based on knowledge of the basic laws of mathematical, natural science and general professional disciplines using information and communication technologies. One of the indicators of possession of this competence is an ability to use basic natural science disciplines' principles to complete standard tasks in aquatic bioresources' and aquaculture's area.

It is important to note that for the full formation of a particular competence the student must have basic knowledge that allows him to master the proposed material and form the required skills. It is necessary to identify and eliminate the gaps in areas of expertise relating to fundamental aspects of natural science knowledge because of significant difference between levels of school educating in subjects of the natural science cycle for full formation of general professional competences.

The generalized hypothesis of this study is the assumption that it is necessary to develop methods for measuring the degree of students' formation of the natural science knowledge and the implementation of blocks aimed at forming/consolidation of the basic provisions of natural science disciplines in educational and methodological complexes of disciplines.

The aim of this article was an examination of forming of fundamental understanding of the basic laws of natural science disciplines by the first year students, preliminary assessment of their readiness to increase their knowledge of fundamental natural science principles.

In addition, the formation of this understanding was studied among 4th-year students who studied according to the standards of the Federal state educational standard (FSES) 3+, but most of the subjects presented in this educational program are preserved regardless of changes in the standard. This research is expected to last for a long time.

2 Materials and methods

The research which is presented in this article was conducted in order to identify the formation of natural science knowledge by 1st-yaer and 4th-year students. The research took the form of a questionnaire including the questions which were related to fundamental elements of the natural science knowledge. The questionnaire included questions with extended responses and the questions with the list of answers to choose one or few of them. This work is a part of a large-scale research aimed at identifying the formation of a natural science knowledge among students of the specialty 35.03.08 which is necessary for the development of methods for a more complete and systematic formation of a natural science knowledge of the world around.

The first group of questions (A) on which was based the assessment of students' total stock of attitudes contained 10 question related to basic provisions of the natural science knowledge. Responders' answers were rated on a 5-point scale depending on extent of coverage the topic from 0 (the topic is not covered) to 5 (the topic is fully covered; the student has formed an idea of the material foundations of the world around).

The second group of questions was dedicated to parascientific knowledge. 5 questions were related to ideas about the immaterial essence, features of time processes, common and well-established ideas about non-scientific knowledge. The answers were also rated on a 5-point scale from 0 (responder does not take into account the basic natural science concepts, the ideas about the methods of scientific knowledge are not formed) to 5(student is able to distinguish between a scientific and an unscientific approach to the issue).

The third group of questions was devoted to basic knowledge in the field of biology as the basis for future professional activity. It contained questions about the structure of living organisms (1 group of questions) as well as questions about the influence of features of molecular and cellular structure at various levels of organization of living organisms on physiological processes. An important aspect of possession of fundamental knowledge in the field of natural science basics of this specialty is the understanding of relationship between the structure and the physiological functions performed by structural units of living organisms. Besides, the possession of the mentioned information and the readiness to apply it tested by the 2nd group of questions indicates the readiness to master more complex professional knowledge, skills and abilities than the basic natural science concepts.

In the research took part DSTU students trained the specialty 35.03.08 "Aquatic bioresources and aquaculture". They were divided into 2 samples: 1st-year students studying for the first time in the FSES 3++ (N0 = 60), and senior students (N1 = 38).

Participation in the questionnaire was voluntary. The questionnaire was conducted in 2019.

The data obtained as a result of the questionnaire were qualitative and quantitative analyzed. The extended responses were researched by content-analysis: certain concepts that could be expressed in different terms by different respondents were identified. Mathematical data processing was performed by use of the statistical tools of the open application LibreOffice 5.4 Calc and the mathematical package R-Portable_3.6.3. To evaluate the differences was used Fischer's nonparametric F-test ($p \leq 0{,}01$). To evaluate the linear correlation of variables whose distribution is close to normal was used the Pearson's correlation coefficient. To evaluate the correlation of data series expressed in the interval scale and in the dichotomous scale, was used a biserial correlation coefficient with an additional assessment of the significance of the result by use of Student's t-test. To analyze correlations of data series that do not have a normal distribution, was used the Kendell's correlation coefficient τ with verification with use of Student's t-test.

3 Results

The initial data analysis revealed that the results of the assessment of students ' natural science concepts vary significantly depending on the subject of questions, even within the group. According to this we considered appropriate to analyze the answers on the group a questions depending on their theme. The first five questions are devoted to generally accepted cosmological ideas about the origin and structure of the universe in general and the Solar system in particular. The results of the assessment of theserated on a 5-point scale questions are presented in the table 1.

Table 1. The average score values for questions on cosmological concepts (group A).

Sample	Question's number					Average score	Standard deviation	Student's t-test
	1	2	3	4	5			
N_0	3	3.7	3.75	3.76	3.23	3.488	0.48	0.4
N_1	3.6	3.73	3.55	3.1	3.86	3.568	0.49	

Average score of 4th-year students is higher, however Student's t-test revealed that the differences between the samples are irrelevant. It demonstrates that there are no fundamental differences in the formation of cosmological concepts of 1st-yaer and 4th-year students. However, the Fisher's F-test was applied for more detailed consideration of the issue taking into account the differences between the questions. The number of students whose answers were assessed with 1 or 2 points (false answer) and the number of students whose answers were assessed with 3,4 or 5 points (correct answer) were counted in order to identify how accurate are the differences between two test subjects' groups. For questions number 3 and 4,the value of the Fischer's F-test demonstrated that there was a significant difference in knowledge levels by 1st-yaer and 4th-year students and the average score showed that1st-yaer students had better results (table 2).

Table 2. The ratioof correct and incorrect answers to questions about cosmological concepts (group A).

Question's number	The number of students who received a score of 1-2 in the sample N_0	The number of students who received a score of 1-2 in the sample N_1	The number of students who received a score of 3-5 in the sample N_0	The number of students who received a score of 3-5 in the sample N_1	Fisher's F-test
1	21	6	39	32	2.166
2	6	8	54	30	1.5
3	6	12	54	26	2.65
4	1	14	59	24	5.026
5	10	6	50	32	0.116

The second part of the group A questions was devoted to fundamental biology issues and related to them physical laws (for example state the simplest version of the law of conservation of matter).The average score is significantly higher by the 1st-yaer students, but the Student's t-testanalysis does not allow us to confirm significant differences (table 3). However, it is noticeable that the average score for 9 and 10 questions is significantly lower by 4th-year students compared to 1st-year students, but in both samples, the highest percentage of minimum points was found for these questions.

Table 3. The average score values for the questions on natural science basic provisions (group A).

Sample	Question's number					Average score	Standard deviation	Student's t-test
	6	7	8	9	10			
N_0	4.46	3.9	4.25	2.23	3.15	3.598	0.6663	0.9
N_1	4	3.86	3.76	1.94	1.65	3.042	1.0509	

The analysis of the number of students who gave correct and incorrect answers demonstrated the reliability of percentage differences for questions 8 and 10. And the senior course showed results significantly lower than the first (table 4).

Table 4. The ratio of correct and incorrect answers to questions to basic natural science provisions (group A).

Question's number	The number of students who received a score of 1-2 in the sample N0	The number of students who received a score of 1-2 in the sample N_1	The number of students who received a score of 3-5 in the sample N_0	The number of students who received a score of 3-5 in the sample N_1	Fisher's F-test
6	2	3	58	35	0.984
7	5	6	55	32	1.124
8	1	6	59	32	2.682
9	44	30	16	8	0.632
10	23	33	37	5	5.127

It was quite difficult to interpret the results of the answers to the questions on paranientific knowledge (group B), so the above-average scores were given only to those students who formulated a methodically competent approach to the question, distinguishing between verifiable and non-verifiable positions. In this group of questions, the average score is significantly higher by the 1st-year students, and the calculated Student's t-test shows the reliability of the differences (table 5).

Table 5. The average score values for the questions on parascientific knowledge (group B).

Sample	Question's number					Average score	Standard deviation	Student's t-test
	11	12	13	14	15			
N_0	4.21	3.88	3.6	4.21	3.7	3.92	0.06	3.6
N_1	3.68	3.15	3.36	2.81	3.21	3.24	0.08	

The analysis of total number of correct and incorrect answers also demonstrated the quality of formation of ideas about the difference between paranientific and scientific knowledge. For all questions, the calculated φ-test showed significant differences, except for 13 questions, where the value of the test lies in the area of uncertainty (table 6).

Table 6. The ratio of correct and incorrect answers to questions on parascientific knowledge (group B).

Question's number	The number of students who received a score of 1-2 in the sample N0	The number of students who received a score of 1-2 in the sample N1	The number of students who received a score of 3-5 in the sample N0	The number of students who received a score of 3-5 in the sample N1	Fisher's F-test
11	1	8	59	30	3.343
12	5	13	55	25	3.208
13	6	9	54	29	1.799
14	1	18	59	20	6.063
15	1	9	59	29	3.642

We considered it appropriate to conduct the analysis of group C questions on general biological issues related to the areas of knowledge that students need in their professional activities in accordance with the specifics of the issue. The questions from 16 to 20 required simple reproduction of factual knowledge. In this group of questions, a higher average score was again demonstrated by the 1st-year students, but the calculation of the Student's t-test did not show a significant difference in the samples (table 7).

Table 7. The average score values for questions on general biological factual knowledge (group C).

Sample	Question's number					Average score	Standard deviation	Student's t-test
	16	17	18	19	20			
N_0	4.63	3.6	4.26	3.81	3.73	4.01	0.146	2.2
N_1	4	3.31	3.36	3.02	3.63	3.46	0.109	

The result of ratio of correct and incorrect answers demonstrated the reliable difference for 16 and 19 questions and such as in previous cases the 1st-year students had better results (table 8).However, in every case the average score was higher than 3, and the number of correct answers was higher than incorrect.

Table 8. The ratio of correct and incorrect answers to questions on general biological factual knowledge (group C).

Question's number	The number of students who received a score of 1-2 in the sample N0	The number of students who received a score of 1-2 in the sample N1	The number of students who received a score of 3-5 in the sample N0	The number of students who received a score of 3-5 in the sample N1	Fisher's F-test
16	1	9	59	29	3.642
17	17	11	43	27	0.068
18	7	8	53	30	1.235
19	10	15	50	23	2.499
20	13	9	47	29	0.227

A different picture was shown by the questions of group C, formulated in such a way that the fact, the knowledge of which was checked by the previous question, formed the basis for the interpretation of the physiological process. To correctly answer the questions of this group, it was necessary not only to know the factual basis of the subject, but also to interpret the fact using a systematic approach and logical thinking. The questions were designated as 16A-20A to link them to questions containing the factual basis on which the reasoning should

be based. However, the average score in both samples was significantly lower than in the previous question groups, and the differences between the samples were unreliable (table 9).

Table 9. The average score values for questions related to physiological processes (group C).

Sample	Question's number					Average score	Standard deviation	Student's t-test
	16a	17a	18a	19a	20a			
N_0	2.28	2.81	2.33	2.26	2.81	2.5	0.065	0.5
N_1	2.23	2.44	2.71	2.5	2.21	2.42	0.034	

Table 10. The ratio of correct and incorrect answers to questions about physiological processes (group C).

Question's number	The number of students who received a score of 1-2 in the sample N0	The number of students who received a score of 1-2 in the sample N1	The number of students who received a score of 3-5 in the sample N0	The number of students who received a score of 3-5 in the sample N1	Fisher's F-test
16a	37	27	23	11	0.965
17a	30	24	30	14	1.288
18a	34	24	26	14	0.637
19a	41	19	19	19	1.809
20a	23	24	37	14	2.426

For the majority of ratios of the total number of correct and incorrect answers, no reliable differences were confirmed (table 10), the values of the f-test showed unreliability, or lay in the zone of uncertainty.Only for question 20A the differences are reliably confirmed, and the N0 sample shows a higher average score. In this group of questions, as in the previous ones, the 1st-year students show a slightly higher score.

4 Discussion

Based on these results we can consider that the hypothesis about the poor formation of the system of natural science basis for the formation of General professional competencies is confirmed. Analyzing the results of the assessment of questions from all groups, we can talk about a higher average score demonstrated by 1st-year students. Of course, this does not mean that 4th-year graduates are less prepared than 1st-year students. However, the content of group A questions , for example, assumes that the student remembers the school course of natural Sciences well enough, and supplements its content with disciplines, the content of which combines basic natural science information with information necessary for various fields of professional activity, for the specialty 35.03.08 such as "Histology and General embryology".

The extremely low average score received by 4th-year students for questions related to the basic course of physics, matter and its properties indicates that there is no information support for these fundamental concepts, although the law of conservation of matter and energy is the basic concept for a number of topics related to the biochemistry of energy exchange, nutrition physiology, the basics of feeding and feed production. For 1st-year students, the survey revealed both a higher value of the average score, and a greater number of people who gave the correct answer to the question. However, the 1st-year student's average score for group A questions 9 and 10 is 2.23 and 3.15, respectively, which is significantly worse than most results for other questions. This can be explained by the fact that students of the specialty 35.03.08 do not have to present the results of the unified state

exam in physics, as a compulsory exam. Therefore, the last year of school education is actually devoted only to the study of subjects necessary for admission to the University. This negatively affects the system formation of the natural science knowledge of the student. The part of a study on the parascientific knowledge attracts special attention. In fact, these questions are related to the properties of matter and ideas about material phenomena. To separate the fields of the knowable and the unknowable, the student must have a basic understanding of scientific methods of cognition. For group B questions, the study showed significant (reliable) differences in the results of the 1st-yearand 4th-year student's survey. The 1st-year students were able to answer questions more clearly and logically and showed a significantly higher percentage of correct answers for all questions. The lower grades and lower percentage of reliable responses of 4th-year students can be explained by the specialization of their professional interests and avoiding the General provisions of scientific knowledge during the professional disciplines'studying. An analysis of the data obtained during the processing of responses to group C questions that were directly related to the biological basis of professional activity showed that students of both groups answered questions related to a simple statement of facts quite successfully. The average score was 4.01 and 3.46 for the 1st-year and 4th-year students, respectively, although the assessment of the sample data did not show a significant difference between the results. These data demonstrate that the actual content of the disciplines allows students to assimilate a sufficient amount of General biological information. The results of the study of the part of the group C questions that required the analysis of already known information and the presentation of their own considerations and conclusions on the basis of it caused difficulties for both 1st-year students and 4th-year students. Although studies of samples of average scores for this group of questions did not confirm significant differences between the samples, the values of average scores of 2.5 for the 1st-year students and 2.42 for the 4th-year students indicate an unsatisfactory result of this part of the survey. The poor ability of both groups to draw conclusions based on the available information indicates a lack of information processing skills in the 4th-year students and a poor quality of 1st-year students'preparation for the formation of both universal competence 1 and related to it General professional competencies.

5 Conclusions

The progression to the competence structure of higher education assumed the strengthening of logical links between subjects of different courses and specialties due to the systematic implementation of one competence with different disciplines. Obviously, such a ambitious goal cannot be achieved in a short period of time. However, basing on the results of the study, we can say that the formation of important elements of the natural science knowledge in the educational program which was examined is not as high-quality as we would like it to be. Senior students did not show significant progress in understanding the basic scientific laws such as elements of a systematic approach to professional activity, and although most of the differences in the results of the 4th-year and 1st-year students did not confirm their validity, this is obviously not the result that the developers of the educational program were focused on. It is possible that the expansion of the range of pedagogical methods which were used to develop the content and the assessment tools of a number of disciplines will improve the results of mastering the educational program. The scope of the study does not allow us to draw more General conclusions, but an expanded and more systematic study of all stages of the formation of a natural science knowledge could provide grounds for developing new pedagogical approaches to the formation of General professional competencies within the block of disciplines directly based on natural Sciences.

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