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Building a Competency Model Student Training

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Abstract: ***Decision-making in the field of education is a complex, multi-faceted process, in which a large circle of stakeholders is involved. Of no small importance for making a correct decision is the analysis of information coming from participants in the educational process at its various stages. The article proposes a methodology for constructing and applying a competency-based training direction model. The technique is based on the use of developed algorithms for building competency models. Due to the use of the Bayesian network, an assessment of the formation of the level of competence is possible even with missing data, i.e. with unknown results of competency-based tasks. The technique bridges the gap between strictly subject structuring of assessment tools, which does not fully correspond to the competency-building model of constructing the main educational program, and activity-based structuring. The article describes the conduct of two experiments conducted to verify the algorithms proposed in the theoretical part. Experimental testing showed that the developed algorithms, method and methodology are suitable for constructing a competency-based model of discipline and the direction of training. The models built according to the methodology, make it possible to make informed judgments regarding the level of students' competency levelling, as well as to predict student performance. Thus, using the methods of intellectual analysis of educational data, the tasks of decision support are solved.***

Keywords ***: model, competences, initial requirements, functional requirements, general competency, professional competency, Bayesian network.***

I. INTRODUCTION

Making decisions in the field of education is a complex, multidimensional process involving a large circle of stakeholders [1-2].

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decisions in the field of education is a complex, multidimensional process involving a large circle of stakeholders [1-2]. Equally crucial for building an effective decision is the analysis of information received from participants in the educational process at its various stages. Over a long period, information about multiple aspects of the educational process is accumulated in the information systems of educational institutions: about students and their academic performance, teachers and their scientific and educational work [3-5]. Distance learning courses, educational forums, student testing and questioning systems, and much more are being created. Thus, in recent years, a lot of data related to the educational process has been accumulated and continues to accumulate.

In connection with the growth of the use of information technologies in education, an interest has arisen in new methods and approaches, in the automated identification of original, sometimes hidden, relationships in data and their interpretation in the benefits of the decision-maker. There are many tasks in which the methods of statistics, machine learning and knowledge extraction are useful for all participants in the educational process: students, teachers, course developers, methodologists, administrative education officials. However, at present, the theoretical basis for the application of these methods in practical activities has not been sufficiently developed.

Among the essential tasks needed to support decision-making is, first of all, the assessment of the level of competence formation, which is preceded by the construction of a student's competency model. The solution of these tasks using the intellectual data analysis is an actual theoretical and practical task, which the higher school faced in connection with the introduction of the standards of the new generation.

The study aims to develop a model of processes in which the application of algorithms for intellectual analysis of educational data will allow all participants in the educational process to make decisions.

II. METHOLOGY

Defining for the field of education is an educational activity, which, like other activities, is characterized by decision-making tasks. Note that a great influence on the decision-making process in the field of education is exerted by expert assessments of responsible persons, as well as the experience and intuition of teachers based on subjective opinions about the place and role of academic disciplines in the process of preparing a university graduate, participating in the development of curricula and so on.

Thus, the decision-maker bears a great responsibility for its consequences.

A. The process of creating a competency model

To verify the developed algorithms, they were experimentally tested, which consisted of two stages. At the first stage, the competence model of the direction of training students was developed.

The main objective of the second stage was to test the developed models and algorithms for assessing the level of students' competence formation. For this purpose, a competency model in the form of a Bayesian network [6] with three main types of vertices was used: competence, tasks, and discipline.

The prosses of methodology for creating a competency model is shown in Fig. 1.

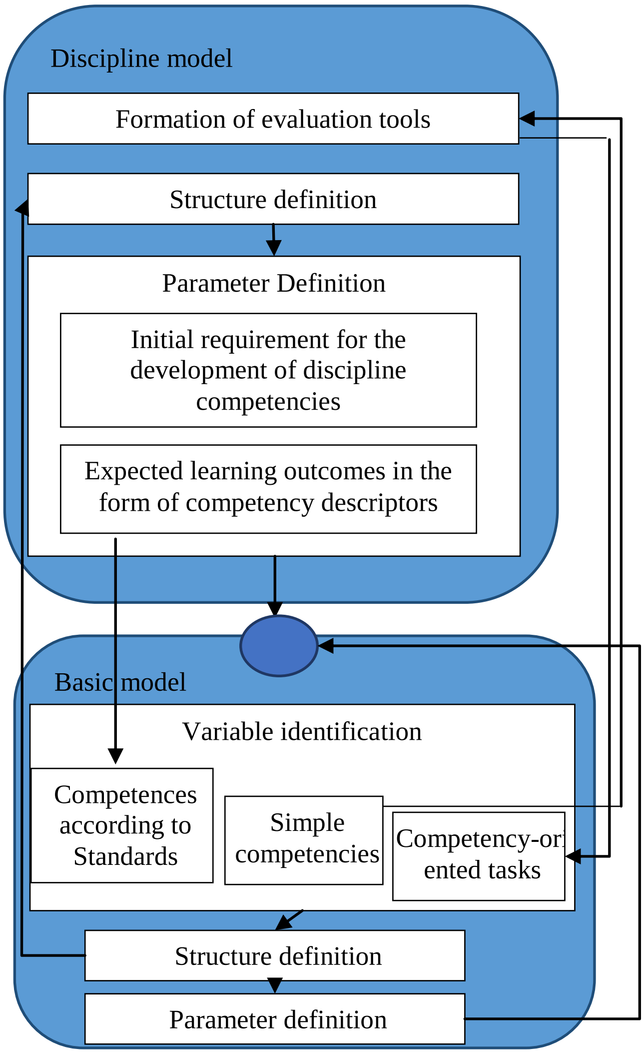

Fig. 1.Methodology for creating a competency model.

B. Model requirements

Before embarking on the formation of a model, it is necessary to formulate several requirements for it. Model Requirements:

1. Compliance with higher education standards.
2. Accordance with the competencies of specialists of the first and second level of higher education.
3. All composite competences must be decomposed into simple ones.
4. Simple competences are associated with the means of their assessment.
5. Disciplines and composite competences of higher education standards are connected through simple competences. Consider these requirements in more detail.

Taking into account the requirements formulated, the Bayesian network with three types of vertices was chosen as a tool for creating a competence model: competences (simple and composite), competence-oriented tasks taking into account the level of complexity, disciplines studied.

C. Competence model based on Bayesian networks

Let us describe the methodology for constructing a competency model of the leading educational program using the example of the "Management" training area. As noted above, the main stages of this process: the identification of variables, the definition of structure, the definition of parameters.

The process of creating a competency model is schematically represented in Fig. 1 in the form of a state diagram. Two composite states are distinguished: the primary model and the model of the discipline. The process begins with the identification of variables in the "basic model" state.

Identification of variables takes place in three stages:

- decomposition of competences of the Federal State Educational Standard of Higher Professional Education to simple competences;
- definition of disciplines for the formation of competencies;
- creation of a fund of appraisal funds following simple competences.

The establishment of links between nodes determines the network structure. The Bayesian network is a tree. In this case, the competency model contains several Bayesian networks.

For a more accurate diagnosis of the level of development, it is necessary to introduce into the network an additional peak (factor) "student training". The top "student preparation" is the parent for the competencies that are required to study the discipline. Estimates of the level of formation of these competencies are evidence. In this way, an assessment of the student's readiness to study the discipline is carried out.

For each discipline a network is built: a model of discipline. The root peak in this network is "academic performance in discipline". A root vertex can have two types of descendants: simple competences (only those related to the discipline are selected), topics (sections) of the discipline. Only the first type is required. The simple competencies that are formed on the discipline are associated with evaluation tools in the form of competence-oriented tasks.

In this case, tasks are descendants, and competences are parents. If there are connections between tasks, it is necessary to apply the vertex copying procedure to preserve the tree structure. An example of a competence model discipline is presented in Fig. 2.

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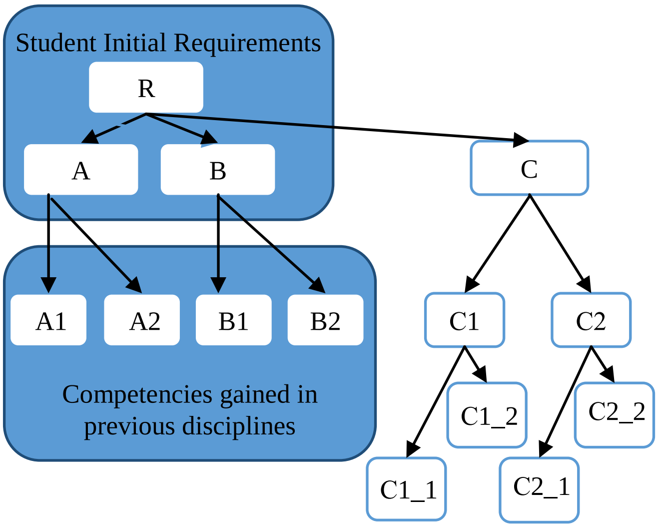

Fig. 2. Example of a competent model of discipline.

To simplify the Bayesian network in this paper, the following restriction is imposed: one competency-oriented task checks only one competency. The mission has a level of difficulty asked by the authors. The level of difficulty of the task is associated with the standards of formation of competencies. The conditional probability at the vertex with the competence-oriented task depends on the value of the difficulty levels.

III. CARRYING OUT THE EXPERIMENT

The experiment is to build a model for the discipline "Culture of business communication". The curriculum in the discipline "Business Communication Culture" is a normative document of the university, which is developed by the department on the basis of the standard of education in the curriculum in accordance with the curriculum of the first level of higher education for students of all forms of study.

The program defines the scope of competences that the bachelor must acquire in accordance with the standard of education, the algorithm of studying the educational material of the discipline "Business Communication", the necessary methodological support, components and technologies of evaluation of educational achievements.

The discipline is taught during the first semester of the 3rd year, consists of lectures provides for the implementation of abstract work and the application of elements of business communication following the curriculum ends with credit.

The discipline should target future professionals to creatively apply the knowledge they have gained in their practical activities.

In the course of studying the discipline focuses on the acquisition of knowledge on the following issues: subject, main categories and objectives of the course "Business Communication Culture"; culture of oral business communication; culture of written business communication; peculiarities of business communication with foreigners; image of a business person; oratory skills of the future specialist; ability to deal with typical communication situations; positions in communication that lead to success; types of conflicts and conflict management.

Modern active personality, having received a basic higher education, becomes the subject of industrial relations, and therefore must acquire both theoretical knowledges of the main categories of the culture of business communication, and put into practice the skills and conventional wisdom of communication.

Purpose of the discipline: formation of professional-communicative competence of future specialists in the field of business communication.

To achieve the goal of studying the discipline, students must learn to solve problems:

- have a holistic view of the business communication process, its structure and stages;
- overcome communication (professional, organizational, individual-psychological) barriers to communication;
- to learn to analyze specific speech situations, recognizing the types of people, their level of morality and other individual features that are manifested in business communication;
- master the system of ways and means of business communication, its strategies, learn how to choose them in accordance with the psychological and socio-cultural characteristics of the interlocutors, to the rules and rules of humanistic ethics;
- learn to apply the chosen methods and means flexibly in the process of communicating with compatriots and foreign partners during individual conversation and collective discussion of problems, in speeches in front of different audiences, in negotiations, in solving conflicts, etc .;
- to outline ways of forming a culture of communication, becoming and self-improvement of the individual style of communication of specialists following ethical and psychological norms and rules.

All this ensures the formation of the competencies that are presented in the table.

Table 1 The competencies of the specialist of the educational qualification level, which are formed as a result of studying the discipline

Function	Typical Competence	Tasks
Ethical	- application of ethical principles and rules, observance of current legislation; - informing on the violation of professional ethics rules - settlement of conflicts of interest, ethical dilemmas; - development of corporate codes of ethics.	1. Know basic ethical principles, requirements of professional organizations and legislation 2. Understand the need to observe ethical standards and technical standards in the performance of professional responsibilities 3. Understand society's expectations of the profession 4. Understand privacy restrictions 5. Provide for possible ethical dilemmas, conflicts of interest and ways of avoiding them 6.Estimate the consequences of unethical behavior for the individual, profession and society
General	- the ability to abstractly think, analyze, synthesize and establish relationships between phenomena and processes; - the ability to communicate.	1. Formulate, analyze and synthesize solutions to scientific and practical problems at the abstract level by decomposing them into components 2. Ability to written and oral communication in the state language and the necessary knowledge of a second language

Let us consider, by way of example, some fragments of the competence model of the "Intellectual systems in the humanitarian sphere" training area (bachelor degree). Identification of variables and determination of the network structure are carried out in accordance with the algorithm.

Directional standards contain two general cultural and six professional competencies. No equivalent competencies were identified among them.

Also, in the list of disciplines, there are causal relationships.

In particular, there is the following wording:

To build a reference model in the first control point, it is necessary to extract disciplines from the curriculum that are studied in the first semester.

These disciplines include:

- Foreign language
- Ukrainian professional language
- Basics of Effective Communication
- Logics
- Ethics, aesthetics
- Psychology
- Physical education

Competences are extracted from the work plans of these disciplines (section "Objectives of mastering the discipline") and Competence-oriented tasks (section "Types and content of training sessions"). A total of 4 general (C1.1, C1.2, C1.3, C1.4) and 4 professional (C2.1, C2.2, C2.3, C2.4) competencies are formed in these disciplines.

These competences are decomposed into components. There are 58 simple competences. Without tasks in the discipline Physical Education, there are a total of 90 tasks that check the formation of competencies. At the same time, several competencies are formed in more than one discipline. Thus, the competence model already in the first semester contains 177 nodes, without taking into account additional ones (composite competences, levels of formation, sections of disciplines). In subsequent semesters, the model only increases its complexity. In this regard, it is necessary to automate the assessment of the formation of competence. The basis of the software implementation is the developed algorithms.

The functional requirements are shown in Fig. 3.

The ability to determine control points based on the curriculum

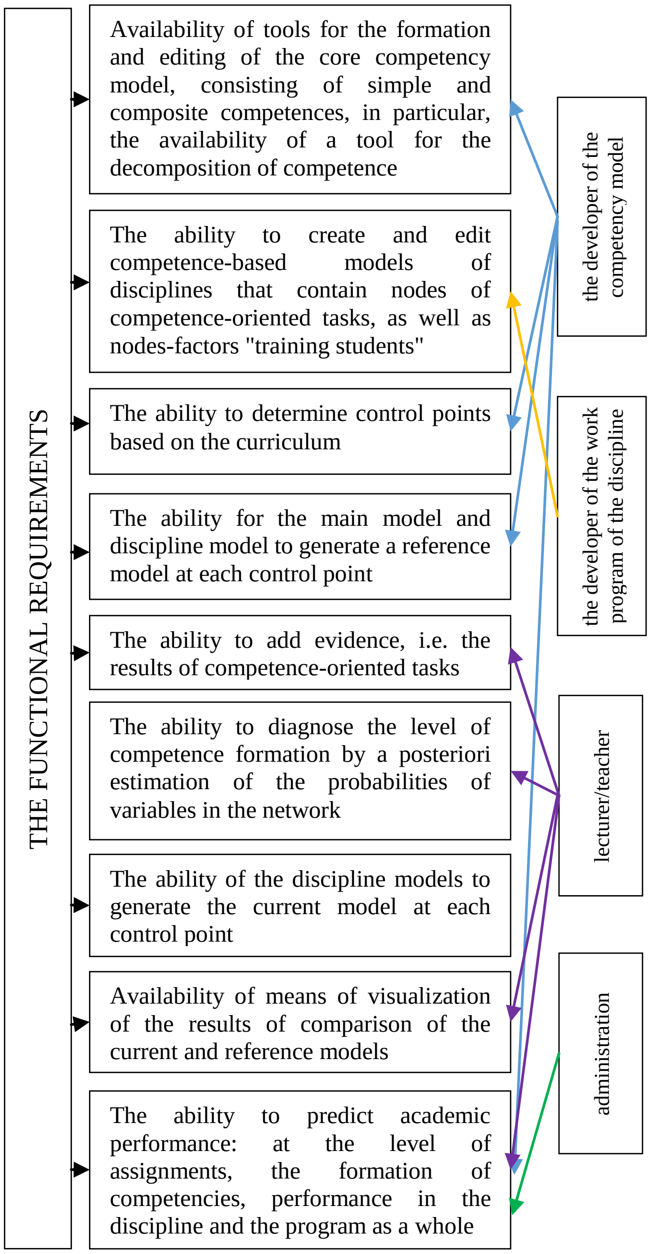

Fig. 3.Functional requirements for the competency model.

IV. COMPETENCE-ORIENTED MODEL

The objectives of mastering the discipline are given by a set of simple competencies with an indication of the required level of their formation. At the same time, for each competency, it is necessary to develop an evaluation tool in the form of a competence-oriented task (COT). In the experiment described, 11 simple competencies were formulated, for each of which one or several tasks should be offered.

The corresponding structure of the Bayesian network, but without COT nodes, is presented in Figure 4.

In the experiment described, each simple competence is associated with one task. For the competencies that make up the initial requirements, the KOZ nodes in the network structure are not taken into account.

This is due to the lack of relevant evidence at the time of the experiment. This circumstance was taken into account as follows. Assessment of students' preparedness (node S) was calculated on the basis of the results of their External Independent Assessment (EIA) and academic performance in previous disciplines responsible for the formation of competencies listed in the "Necessary Conditions for the Development of the Discipline" section.

To create a Bayesian network, we will use a program written in the P language using the gRain package (Fig. 4).

```
# install and connect the necessary libraries
source ("http://bioconductor.org/biocLite.R")
biocLite ("RBGL")
library (gRbase)
library (gRain)
library (Rgraphviz)
# set the level of competencies
lvl <- c ("3", "2", "1", "0")
# set the rating scale
marks <- c ("5", "4", "3", "2", "1")
# we set a priori probabilities for the formation of competencies
# levels are equally likely
A <- cptable (~ A, values = c (25,25,25,25), levels = lvl)
# set conditional probabilities for tasks a1, a2, a3
a1.A <- cptable (~ a1 | A, values = c (80, 10, 5, 3, 2,
                                       80, 20, 10, 3, 2,
                                       70, 15, 15, 3, 2,
                                       2, 3, 15, 30, 50), levels = marks)
a2.A <- cptable (~ a2 | A, values = c (70, 15, 10, 3, 2,
                                       70, 15, 15, 3, 2,
                                       60, 20, 20, 3, 2,
                                       2, 3, 10, 25, 60), levels = marks)
a3.A <- cptable (~ a3 | A, values = c (60, 20, 15, 3, 2,
                                       50, 25, 20, 3, 2,
                                       45, 35, 25, 3, 2,
                                       2, 3, 5, 20, 70), levels = marks)
# build a graph structure with parameters
cpt.list <- compileCPT (list (A, a1.A, a2.A, a3.A))
bnet <- grain (cpt.list)
bnet <- compile (bnet)
# draw a Bayesian network
plot (bnet $ dag)
```

Fig. 4. Code for creating a Bayesian network.

However, this is an incomplete structure. A feature of competence as a result of training lies in its interdisciplinary nature. The consequence of this is the fact that competencies are formed in different disciplines. Figure 5 shows a fragment of the competency-based model of the training direction, showing the structure of the Bayesian network for the connection between competencies, tasks and disciplines.

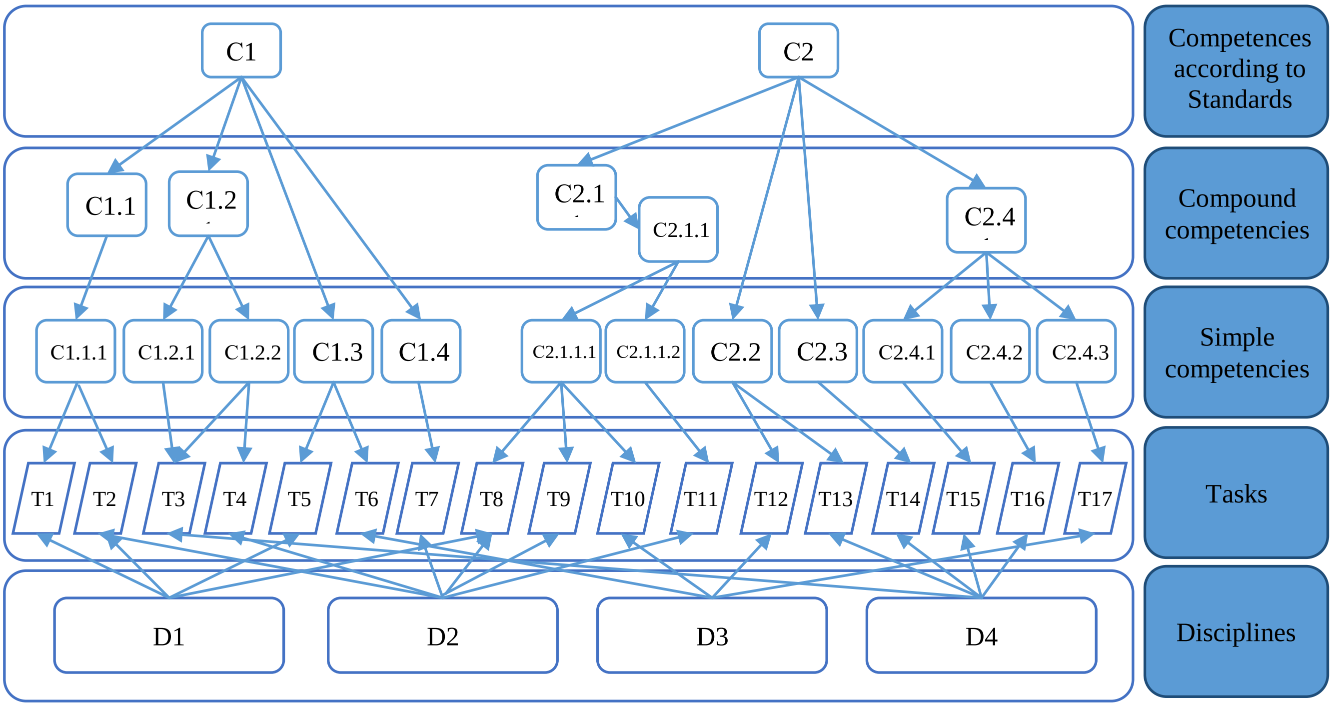

Fig. 5.Competency model of the discipline "Culture of business communication"

The model contains three main types of vertices: competencies (simple and compound), tasks (competency-based), and the studied disciplines.

In the first part of the assignments, the students were provided with a ready-made data set that includes the following features:

- grades of first and second-year students in a number of disciplines;
- gender of students;

- year of graduation and the year of entering the university;
- number of the order of enrollment;
- the city in which the student graduated from school.

Students were required to complete a series of tasks on the submitted data set, for example, write a business letter to a partner from China, solve a conflict situation among subordinates, etc.

In the second part, the students had to independently find a set of data on any topic of interest to them and extract as much information as possible, as well as from the provided "portraits" of staff to hold a meeting, arranging them in the right order and driving according to their psychotype. A total of 24 tasks were formulated (20 basic and 4 complex, of increased complexity) taking into account possible types of connections between tasks. In practice, students received a total of 17 tasks. Table 3.3 shows the relationship between tasks and competencies, the formation of which they check.

Table 3.3 - Relationship of competences and tasks

<table>
<tr><th colspan="4">Competences</th><th>Tasks</th></tr>
<tr><td rowspan="7">C1</td><td rowspan="2">C1.1</td><td colspan="2" rowspan="2">C1.1.1</td><td>T1</td></tr>
<tr><td>T2</td></tr>
<tr><td rowspan="2">C1.2</td><td colspan="2">C1.2.1</td><td>T3</td></tr>
<tr><td colspan="2">C1.2.2</td><td>T4</td></tr>
<tr><td colspan="3" rowspan="2">C1.3</td><td>T5</td></tr>
<tr><td>T6</td></tr>
<tr><td colspan="3">C1.4</td><td>T7</td></tr>
<tr><td rowspan="10">C2</td><td rowspan="4">C2.1</td><td rowspan="4">C2.1.1</td><td rowspan="3">C2.1.1.1</td><td>T8</td></tr>
<tr><td>T9</td></tr>
<tr><td>T10</td></tr>
<tr><td>C2.1.1.2</td><td>T11</td></tr>
<tr><td colspan="3" rowspan="2">C2.2</td><td>T12</td></tr>
<tr><td>T13</td></tr>
<tr><td colspan="3">C2.3</td><td>T14</td></tr>
<tr><td rowspan="3">C2.4</td><td colspan="2">C2.4.1</td><td>T15</td></tr>
<tr><td colspan="2">C2.4.2</td><td>T16</td></tr>
<tr><td colspan="2">C2.4.3</td><td>T17</td></tr>
</table>

The work was done by means of MS Word and the Internet. In this case, the students were given a mandatory condition under which they can jointly discuss the implementation of the task, but cannot share their work.

Feedback from the students was organized in the form of a series of in-person and absentee (remote) consultations. On the website of the department were placed all the necessary training materials for the assignment. Part of the site is a forum (Q & A) in which students can communicate with each other and ask questions to the teacher. The site has a counter that collects user statistics. In particular, such activity indicators as reviewed topics, days on the forum, number of messages, etc. are taken into account.

The final control was carried out in the form of student protection report, prepared by the results of assignments. Reports were sent to the e-mail of the teacher. At the first stage, the reports were tested for plagiarism (min. 20% uniqueness), and then the reports were evaluated on a "completed" or "not completed" scale. Criteria for the performance of tasks are determined by teachers and recorded in the annexe to the work program of the discipline.

As a result, an expert assessment of the formation of simple competences was carried out. When evaluating, probabilities for composite competences were not considered. For a more rigorous conclusion about the assessment of their creation, it is necessary to use the basic competence model, which contains complete decomposition of composite competences. While in the competence model of the discipline is represented only a subset of the constituent elements of competencies. The results were used to train the parameters of the Bayesian network. Due to the small sample size, an empirical estimation procedure was used to generalize the ability of algorithms using the method of sliding control (cross-validation).

At the second stage, the trained network was used to assess the formation of competencies among 18 students.

A point-rating system (PRS) is used to assess student performance in a discipline. The result of this query is a posteriori probability of the student's progress in the discipline, taking into account the evidence obtained, i.e. results of the assignment. Denote TD1 – the set of all tasks in the discipline D1. Then the probability of academic performance is denoted by $p(D1 \mid TD1)$.

V. EVALUATION OF RESULTS

Besides, the results of the first stage of the experiment were used to compare the results of the Bayesian network and the results of PRS. The results of the comparison are presented in table 3.4.

Table 3.4 - Comparison results of Bayesian network estimates with PRS

Student ID	$p(D1 \mid TD1)$	PRS
01	0.87	74
02	0.54	60
03	0.89	92
04	0.96	94
05	0.97	92
06	0.77	82
07	0.65	65
08	0.87	74
09	0.85	90
10	0.96	85
11	0.05	12
12	0.75	74
13	0.89	94
14	0.94	90
15	0.14	22
16	0.98	95
17	0.88	80
18	0.86	82

The data in Table 3.4 demonstrates that the proposed Bayesian network does not contradict the estimates in PRS.

VI. CONCLUSION

Thus, the problem of verifying the results of applying the Bayesian network is solved by applying a network training procedure that provides high accuracy on the test set. Additional comparison with the accepted assessment tool did not reveal any contradictions, thereby confirming the applicability of the Bayesian network for assessing the formation of competencies.

REFERENCES

1. O. Bila, V. Miziuk, T. Gumennykova, A. Kichuk, O. Sagan, L. Perminova The Use of Modern Interactive Technologies in Learning: Correlation Analysis of the Results, *International Journal of Innovative Technology and Exploring Engineering*, Volume-8 Issue-8, June, 2019, pp. 3172-3175
2. I. Bashynska, M. Baldzhy. L. Ivanchenkova, L. Skliar, O. Nikoliuk, G. Tkachuk Decision making under risk: training "investment portfolio", *International Journal of Recent Technology and Engineering*, Volume-8 Issue-2, 2019, pp. 3940-3943 DOI: 10.35940/ijrte.B1729.078219
3. I. Bakhov Historical dimension of the formation of multicultural education in Canada, *Pedagogika*, 117(1), 2015, pp. 7-15. doi:10.15823/p.2015.063
4. M. Holovatyi The state and society: The conceptual foundations and social interaction in the context of formation and functioning of states, *Economic Annals-XXI*, 9-10, 2015, pp. 4-8.
5. O. Prokopenko, R. Holmberg, V. Omelyanenko Information and communication technologies support for the participation of universities in innovation networks (comparative study), Vol. 14, Issue № 3, 2018, pp. 17-29
6. S. Lekar, D. Shumeiko, V. Lagodiienko, V. Nemchenko, O. Nikoliuk, O. Martynyuk The Use of Bayesian Networks in Public Administration of the Economy, International Journal of Engineering and Advanced Technology, Volume-8 Issue-5, 2019, pp. 1419-1421