

The background of the cover is a close-up photograph of a microscope. The objective lens is in sharp focus, with the text 'UPlanFLN 4x/0.13' visible on its barrel. The eyepiece and other parts of the microscope are blurred. A red diagonal stripe is visible in the upper left corner. The title 'REVISTA INCLUSIONES' is printed in large, bold, red capital letters across the center of the image.

REVISTA INCLUSIONES

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TOOLS FOR COURSE PREPARATION IN METRIC COMPETENCE FORMAT

Anis F. Galimyanov

Kazan Federal University, Russia

Nijes Moataz Talal

Kazan Federal University, Russia

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Abstract

Currently, the determination of the quality of training is the most important task. In our work, we use the definition of quality monitoring according to ABC-abilities, which are defined by N.K.Nuriyev and L.N. Zhurbenko. According to them, competence in any field is invariantly supported by the triad of abilities <A, B, C> of a certain level of development, i.e. ABC abilities and knowledge, as auxiliary means, where A, B, C are formalization, constructive and performing abilities, respectively. The course editor in the form of a written application is developed in the form of a web-based student training program that allows to evaluate and visualize the level of ABC - a student's abilities. Based on these results, a decision is made on the trajectory of further education.

Keywords

Abc-abilities – Measurement of the level of training – Visualization of the level of training
Competence – Level of education

Para Citar este Artículo:

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Introduction

In this paper, we rely on the definition of quality monitoring according to ABC-abilities, which are defined by N.K.Nuriyev and L.N. Zhurbenko. According to them, competence in any field is invariantly supported by the triad of abilities <A, B, C> of a certain level of development, i.e. ABC-abilities and knowledge, as an auxiliary means, where A, B, C are formalization, constructive and performing skills, respectively.

Using the spatial model, we define the values of the following criteria:

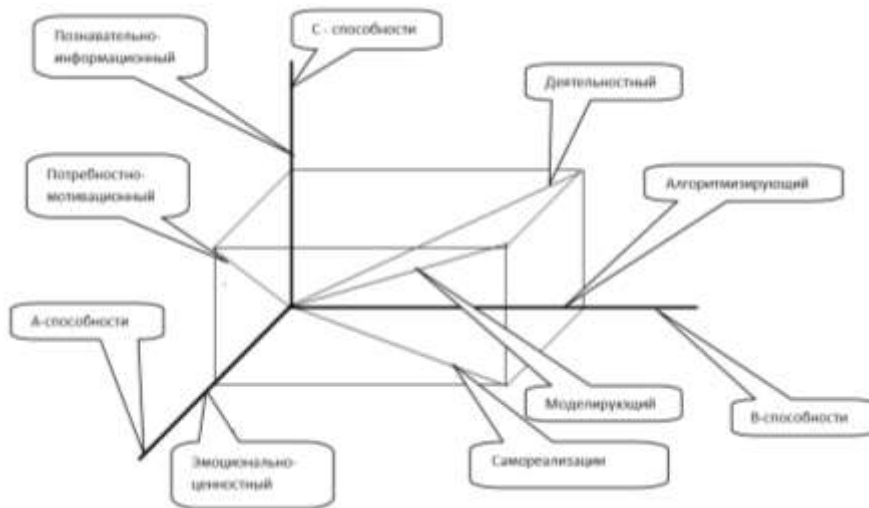


Fig.1
Quality monitoring criteria

- Emotional value criterion = $|A|$
- Design criteria = $|B|$
- Informative-information criterion = $|C|$
- Requirement-motivational criterion = $\sqrt{A^2 + C^2}$
- Activity criteria = $\sqrt{B^2 + C^2}$
- Self-realization criterion = $\sqrt{A^2 + B^2}$
- Modeling criterion = $\sqrt{A^2 + B^2 + C^2}$

In studies devoted to the system analysis of the engineer’s activity, it was found that the probability p (success) of solving a problem by an engineer from a certain competency mainly depends on three factors: the depth of his knowledge, the level of development of design and design abilities, and the complexity of problems to be solved. Formally, this pattern can be written as:

$$P(\text{Успех}) = P(A, B, C, POL, CHL, S),$$

Where the parameters POL, CHL characterizes the depth of knowledge of the engineer, A, B, C - the levels of development of formalization, constructive, performing abilities, and S - the complexity of the problem being solved. Based on this pattern, a competence quality competency scale (KVK) has been built. (Fig.2).

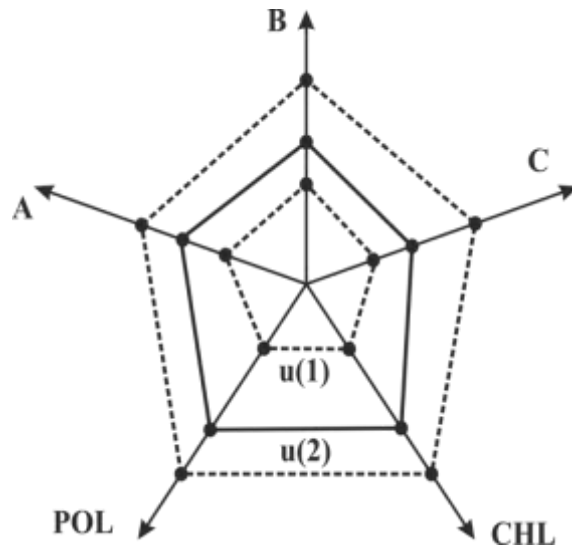


Fig. 2
Competency Quality Scale

On this scale, the engineers $u(1)$ and $u(2)$ have different values of the quality indicators of competence. In general, (statistics do not refute this) the engineer $u(2)$ is more likely to solve the problem of complexity S , which the engineer $u(1)$ cannot resolve.

Based on this statistically not disproved pattern, it is possible to formulate the goal of teaching students in a didactic system with training technology in a metric competence format. (Fig. 3).

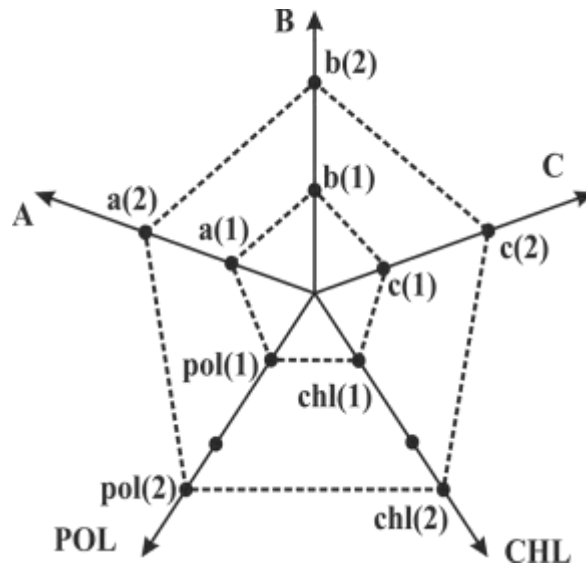


Fig 3
Two student development profiles on the KVK scale

The goal can be formulated as follows: through training (within the competence) it is required to develop a student from profile A (1) -B (1) -C (1) -CHL (1) -POL (1) to profile A (2) -B (2) -C (2) -CHL (2) -POL (2).

It is necessary to develop a system devoid of these shortcomings. Adding a knowledge assessment mechanism to this system will not be of great technical complexity.

According to the goal, a didactic system with training technology in a metric competency format (Fig.4) was designed.

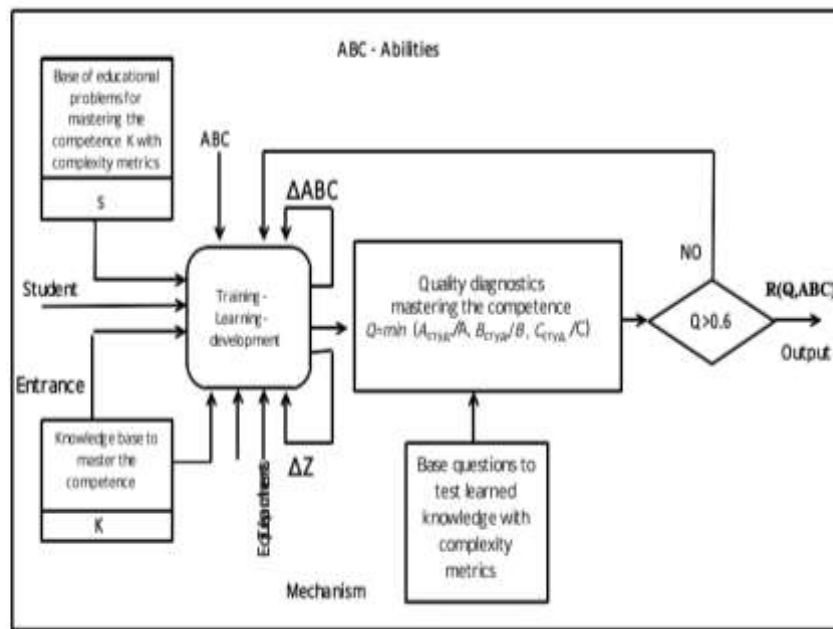


Fig 4

The structure of the organization of the didactic system

The system works as follows. Let the training course consist of n section. Each section is complete, i.e. contains theoretical, practical, diagnostic materials with an assessment of their complexity.

Within the section, theoretical, practical (learning problems and tasks) materials are mastered. At the same time, the student, within the framework of each section, through his educational activity, increases (in metric units) the levels of development of ABC abilities by ΔABC and deepens knowledge by ΔZ . At the end of the section, the student is diagnosed, i.e. passes the test. The teacher assesses the quality of the assignment (from 0 to 1). Levels of development ABC - abilities are evaluated with a graphical interpretation of achievements. The heuristically found a minimum threshold for the permissible quality of competence within a section is taken to be 60%. If the indicator of the quality of development exceeds 0.6, then you can proceed to the development of the next section. Due to practical feasibility, we will include in this system only ABC assessments of students' skills. Then the quality scale of competence will be as follows:

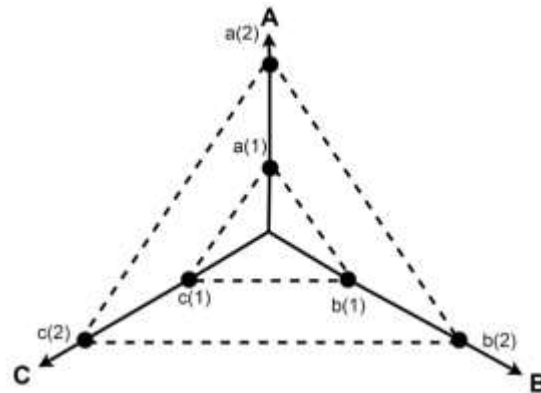


Fig 5
Two student development profiles on the KVK (ABC) scale

Training at the level of the graduating department is organized as follows. To master the list of competencies according to the GEF, a library of automated training courses is organized on the web network (Fig. 5).

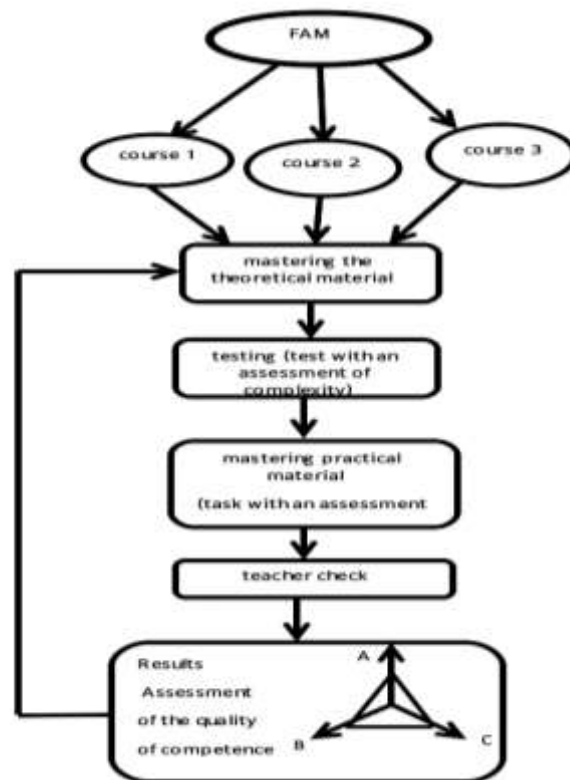


Fig 6
Organization of the library of training courses

Each course is organized in the same way (Fig. 6).

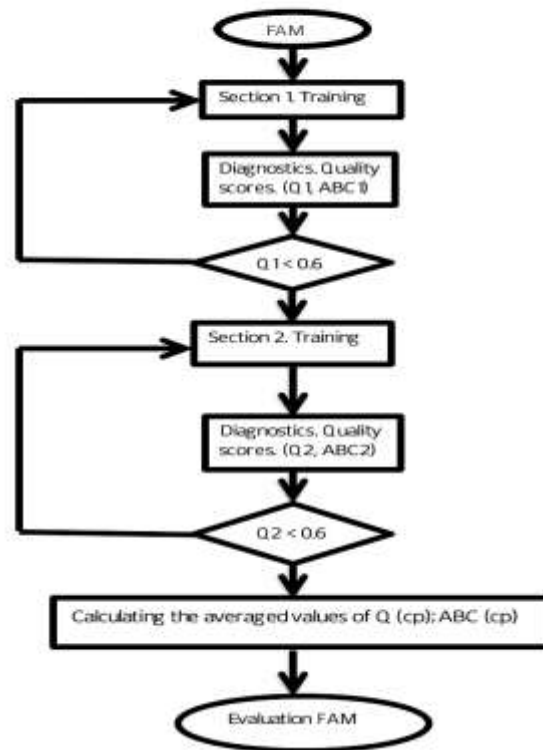


Fig 7
Course organization chart

Note that in this system, in contrast to the previous one, the teacher does not evaluate the student's result, but the content of the task as a subject of difficulty for each of the criteria.

As a result of the system, we get a score of ABCs - student abilities, which can correspond to one of the following levels: high, medium, satisfactory, mediocre.

To calculate the ABC abilities of a student, it is necessary to evaluate the complexity of the course according to A, B, C criteria. This assessment is performed by the teacher when creating the course. The teacher assesses the tasks and tests he creates for each of these criteria. During the course, the student goes through the sections, answering the test questions and solving problems. The teacher evaluates the student's decisions. Assessment of the tasks and questions of the test on the A, B, C criteria allows you to calculate the levels of ABC student abilities after the course

Each course can consist of an arbitrary number of sections. Let n - the number of sections in the course. For each section, it is necessary to determine the complexity of the A, B, C criteria. Then we can describe the complexity of the course with an $n \times 3$ matrix, where the row number determines the section number, the column number is the criterion, and the element values define the

complexity of the section by the criterion. The first column corresponds to criterion A, the second - B, the third - C. These values are not set directly by the teacher, but are calculated based on the content of the section, i.e. from the complexity of the issues and tasks. For example, the value of the element $s_{2,3}$ describes the complexity of criterion C of the second section of the course¹.

$$S = \begin{pmatrix} s_{1,1} & s_{1,2} & s_{1,3} \\ s_{2,1} & s_{2,2} & s_{2,3} \\ \dots & \dots & \dots \\ s_{n,1} & s_{n,2} & s_{n,3} \end{pmatrix}$$

So you can get A, B, C course complexity:

$$A = \sum_{i=1}^n s_{i,1}, \quad B = \sum_{i=1}^n s_{i,2}, \quad C = \sum_{i=1}^n s_{i,3}.$$

We can also describe each section using matrices Q_k of dimension $m \times 3$ and T_k of dimension $p \times 3$, where k is the number of the section, m is the number of test questions, p is the number of tasks. The Q_k matrix corresponds to the test questions, the T_k matrix corresponds to the tasks. The rows correspond to the tasks (test questions), the columns also meet the criteria.

$$Q_k = \begin{pmatrix} q_{k1,1} & q_{k1,2} & q_{k1,3} \\ q_{k2,1} & q_{k2,2} & q_{k2,3} \\ \dots & \dots & \dots \\ q_{km,1} & q_{km,2} & q_{km,3} \end{pmatrix}$$

$$T_k = \begin{pmatrix} t_{k1,1} & t_{k1,2} & t_{k1,3} \\ t_{k2,1} & t_{k2,2} & t_{k2,3} \\ \dots & \dots & \dots \\ t_{kp,1} & t_{kp,2} & t_{kp,3} \end{pmatrix}$$

The values of these matrices are determined by the teacher when he assesses the test questions and tasks when completing the section. The complexity of the section according to the criterion is the sum of the difficulties of the test questions and the tasks of this section according to the corresponding criterion and is subsequently calculated as follows:

$$s_{i,j} = \sum_{c=1}^m q_{i,c,j} + \sum_{c=1}^p t_{i,c,j}.$$

Also for each section links are established with the previous sections for each of the criteria. They are defined as an R_k matrix of dimension $(k-1) \times 3$,

¹ E. A. Pecheny; N. K. Nuriev and S. D. Sarygina, Economic and mathematical models in management: studies. Allowance (Kazan: Center for Innovative Technologies, 2016).

where k is the current section number. The values of this matrix are determined by the connection with the previous sections to one of the criteria A, B, C. The line number determines the number of the previous section, and the column number determines the criteria. The values of this matrix can take values from the set $[0,1]$, where 0 is defined as the absence of a bond, and 1 as a strong bond. These values are also determined by the teacher.

$$R_k = \begin{pmatrix} r_{k1,1} & r_{k1,2} & r_{k1,3} \\ r_{k2,1} & r_{k2,2} & r_{k2,3} \\ \dots & \dots & \dots \\ r_{kk-1,1} & r_{kk-1,2} & r_{kk-1,3} \end{pmatrix}$$

To complete the course, the student must complete all sections of the course. After passing each section, the student receives an assessment for each of the criteria. After passing through all the sections, we obtain a matrix of $n \times 3$ students' grades according to criteria A, B, C.

$$S_{\text{студ}} = \begin{pmatrix} S_{\text{студ}1,1} & S_{\text{студ}1,2} & S_{\text{студ}1,3} \\ S_{\text{студ}2,1} & S_{\text{студ}2,2} & S_{\text{студ}2,3} \\ \dots & \dots & \dots \\ S_{\text{студ}n,1} & S_{\text{студ}n,2} & S_{\text{студ}n,3} \end{pmatrix}$$

During the passage of each section, the student answers the test questions and solves problems that are subsequently verified by the teacher. After passing the section, we obtain the vectors of estimates $a_k = (a_{k_1}, a_{k_2}, \dots, a_{k_m})$ and $b_k = (b_{k_1}, b_{k_2}, \dots, b_{k_p})$ for answers to test questions and tasks, respectively. Values a_{k_i} takes values from $\{0,1\}$, where 0 corresponds to an incorrect answer to i question, and 1 corresponds to the correct answer. Meanings b_{k_i} takes values from $[0,1]$, where 0 corresponds to the wrong solution for i problem, and 1 - completely correct. The results of the section for each of the criteria are calculated as follows:

$$S_{\text{студ}i,j} = \sum_{c=1}^m a_{k_c} q_{k_c,j} + \sum_{c=1}^p b_{k_c} b_{k_c,j}$$

If the student's result for each of the criteria A, B, C exceeds the threshold of 60% of the complexity of the section according to this criterion, i.e.

$$\frac{S_{\text{студ}i,j}}{S_{i,j}} \geq 0.6,$$

This section is considered passed. For each of the criteria, depending on the result, the level of the student is determined.

Level	Minimum percentage
Mediocre	60%
Satisfactory	70%
Average	80%
Tall	90%

If a student does not receive 60 percent or more by all criteria, then the section is considered not completed. In this case, if there is a section with number l , the result of which according to any of the criteria satisfies the following condition:

$$\left(\frac{S_{\text{студ}i,j}}{S_{i,j}}\right) \leq 0.6 + 0.4 \cdot \left(\frac{S_{\text{студ}i,j}}{S_{i,j}}\right) \cdot R_{k,i,j}, i < k,$$

where k is the number of the current section, then the student must pass the previous section before passing the current section. If there is no such section, or the current section is the first, the student re-passes the current section.

After passing all sections, the levels of ownership are calculated $A_{\text{студ}}$, $B_{\text{студ}}$, $C_{\text{студ}}$ ABC abilities for this course:

The following criteria are also calculated:

A (Emotional Value) criterion: $A_{\text{студ}} = \sum_{i=1}^n S_{\text{студ}i,1}$,

B (Constructive) criterion: $B_{\text{студ}} = \sum_{i=1}^n S_{\text{студ}i,2}$,

C (Cognitive informational) criterion: $C_{\text{студ}} = \sum_{i=1}^n S_{\text{студ}i,3}$,

A-B (Self-Realization) criterion: $\sqrt{A_{\text{студ}}^2 + B_{\text{студ}}^2}$,

A-C (Requirement-motivational) criterion: $\sqrt{A_{\text{студ}}^2 + C_{\text{студ}}^2}$,

B-C (Activity) criterion: $\sqrt{B_{\text{студ}}^2 + C_{\text{студ}}^2}$,

A-B-C (Modeling) criterion: $\sqrt{A_{\text{студ}}^2 + B_{\text{студ}}^2 + C_{\text{студ}}^2}$.

Methods

To develop this web application, Java was used as the main programming language. This language has a convenient syntax and a large number of libraries, it allows you to accelerate the development of applications. Also, this programming language allows development under a large number of different operating systems.

SQLite relational database is used for data storage. SQLite is a compact database that does not require a separate process to work with it. To work with it there are many libraries for various programming languages.

As a framework for developing a web application, the Play Framework was used. This framework uses the Model View Controller design pattern. It has a

built-in web server, Netty, which allows for rapid deployment of applications. It also has a convenient template engine based on the Scala programming language.

To connect the database and models used in the development of the Play Framework, the object-relational mapping library Ebean ORM was used.

To develop the look and feel of this web application, HTML markup language and

CSS style sheets were used. To speed up and ease the design of a web application, HTML and CSS framework Bootstrap was used. We also used code inserts in the JavaScript programming language. For visualization of the results JavaScript of the chart.js library was used. Ckeditor was used as a visual text editor.

Results

The IDE (integrated development environment) IntelliJ Idea was used in the development. It is a convenient development environment with many different functions. It supports many programming languages, including Java. It has built-in support for the Play Framework.

Thanks to these tools and technologies, the developed web application can be quickly installed and used on various operating systems.

Implementation and review (practical part)

To develop this web application, Java programming language and Play web framework was used. SQLite database was selected for data storage. HTML and CSS framework bootstrap was used to design this web application, the jQuery library was also used. The ckeditor visual text editor was also used. For visualization of results, the chart.js library was used. When implementing this web application, IntelliJ Idea was used.

There are 3 types of users in this web application:

- Administrator
- Teacher
- Student

When working with this editor, the administrator assigns teachers. The teacher can create and edit one or more courses. (Fig. 8)



Fig. 8
The window of course creation and editing

Each course should be divided into topics that include:

- Theoretical material
- Test
- Task set



Fig 9
Topic editing window

For each task and question in the test indicates the complexity for each of the parameters A, B, C. For filling out lectures, tests, or tasks there is a visual text editor with the possibility of adding media materials. (fig.10)

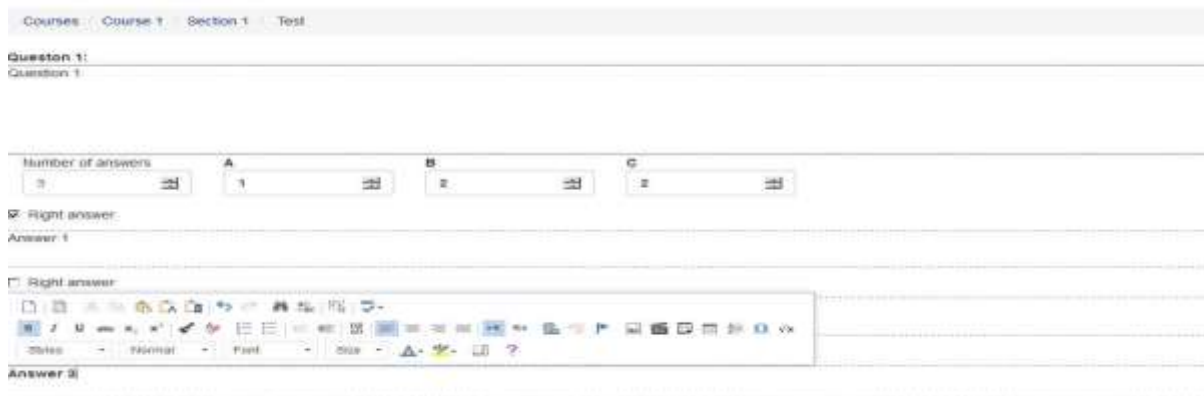


Fig 10
Topic editing window

Also for each topic, you must specify the number of questions in the test, the number of tasks and A, B, C links with previous topics. (Fig.11)

Section settings

Number of questions in test: 3

Number of tasks in block: 1

Relation with previous themes:

Theme name	A	B	C
Section 1	0.1	0.3	0.5
Section 2	0.6	0.4	0.7

Buttons: Add theory, Add tests, Add task blocks

Fig 11
Ability gradation window

Next, you need to select students for the course and open access to them. (Figure 12.)

Access control

Enter last name

First name	Last name	Email	Access
Admin	1	admin	Open access
Lecturer	1	email1@domain.com	Open access
Student	2	email2@domain.com	Open access

Close

Fig 12
Access the editing window

With the course, the student studies the theoretical material, passes the test, and solves the problem. After checking the task by the teacher, the results for this topic are calculated. If a student's score on one of the criteria A, B, C, is less than the threshold, then to try again, he needs to go through previous topics that are related to this one by the corresponding criterion. The student and teacher can view the visualization and description of these results. (Fig.13)

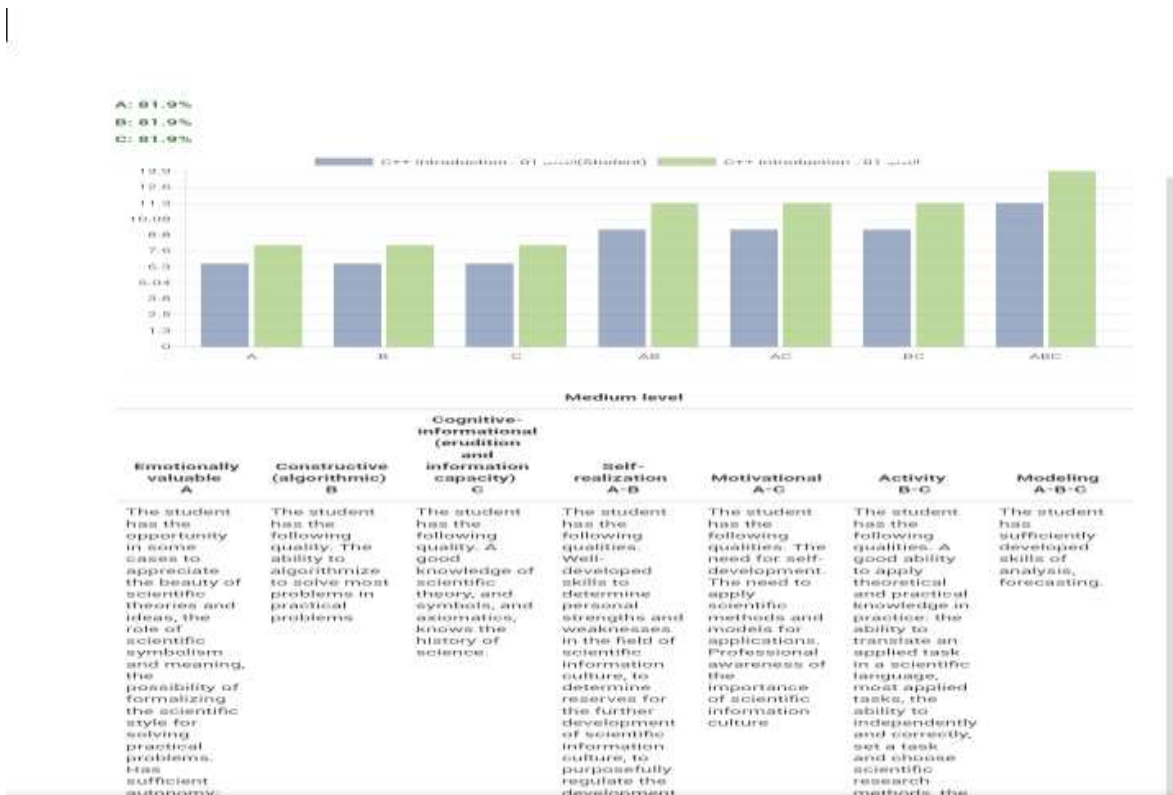


Fig 13
Interim result visualization window

After completing the course, it is possible to view the visualized general results, as well as the student's answers to the test and tasks. (Fig.14)

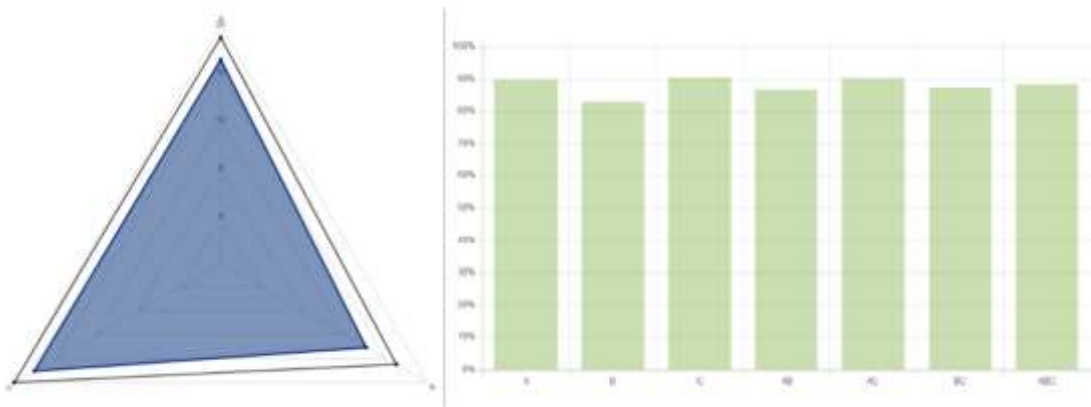


Fig 14
General result visualization window

Conclusion

Following the task, the course editor was developed in the form of a web-based application for the adaptive preparation of students, allowing to evaluate and visualize the level of ABC - student abilities.

The system provides teachers with a convenient interface for creating courses, allows you to monitor students' preparation and automatically evaluate students by all criteria (cognitive-informational, emotional-axiological, constructive-algorithmizing, need-motivational, modeling, self-realization, activity), view results in text and graphic form.

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