Automation of the process of measuring the level of competence development in a competence-oriented learning

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Abstract. The paper describe methods and tools of monitoring the development of competencies within the framework of a competency-based training model. A formalized model for assessing competencies throughout the educational period is presented. The paper considers the classification of information collected.

1. Introduction
The main method of monitoring the quality of education for specialists is the use of a fund of valuation tools (FVT). Thus, FVT allows measuring the level of development (formation) of competencies. FVT is a set of methodological and control measuring materials intended for assessing competencies at different stages of students' education, as well as for certification tests for compliance with requirements (or non-compliance) with their training levels by Federal State Educational Standard on completing the development of the main educational program in a particular specializations. [1].

Assessing the current situation in higher education, we can conclude that in the most cases the main method is application of traditional methods for assessing the quality of learning the educational material. Classical testing has established itself as an effective method of assessment, in additional it simplicity of control at the start of education, brief questioning, assessing of knowledge in different part of education process, etc. In modern conditions of educational process, testing gives a result with a strong delay, which in most cases does not provide an opportunity to correct the situation, especially if testing is carried out as a final (last) certification.

2. Sources classification of information about the educational process
Like a traditional learning process, most educational institutions use additional support systems for the educational process in the form of information systems and technologies. In accordance with the Federal State Educational Standards of Higher Education, each educational institution should have an electronic information environment for expanding the possibilities of traditional education. As a result of analyzing current trends in the educational process, the requirements of the legislative framework in the field of education and the theory of information systems and technologies, we can conclude that the sources of educational process data by the processing method can be divided into:
   a) sources of automatic collection and storage of information;
   b) sources of automated collection and storage of information;
   c) sources of manual collection of information.
2.1. **Sources of automatic collection and storage of information.**

Different events which exist in e-learning as part of the educational process can be recorded automatically. Events it is a sources of automatic collection and storage of information. Such sources include events:

- entrance to electronic library systems (date and time of access);
- viewing literature in library systems (date and time of access, viewing duration);
- entrance to the personal account of the electronic information and educational environment (EIEE, e-learning system) (date and time of entry);
- viewing of educational sections of EIEE (date and time of entry, duration of stay in EIEE, types of sections viewed);
- activity during synchronous and asynchronous interaction (date and time of publication, topic of publication);
- performance of tests implemented as a part of educational technologies (date and time of passing, mark for the test, number of attempts);
- realization of the elements of educational technologies within the framework of the EIEE (information of complete of a particular element, the total percentage of realization of educational elements in the electronic course of educational technology);
- launch of an interactive course as a part of educational technology (date and time of launch, number of starts, percentage of completion, assessment of completion, duration of completion, number of attempts to complete the contents of the interactive course);
- launching of the virtual desktop (launch date and time, duration of work, used software);
- launching the application throw virtual laboratories (date and time, duration of work).

2.2. **Sources of automated collection and storage of information.**

Sources of automated collection and storage of information allow to collect information which sent personally by students and teachers. Data from students is collected in an automatic mode but evaluated manually. Work in electronic form is semi-automated, because the student must send the work on their own, but the teacher must evaluate the work in person.

The source of automated data collection includes:

- task which sent electronically in the EIEE;
- tasks performed as part of the virtual computer laboratories;
- tests (as a part of EIEE) which requiring assessment in manual mode;
- student portfolio.

2.3. **Sources of manual collection of information.**

Sources of manual collection of information are characterized by the fact that they are performed in manual mode. Data is entering into the information system for storage and further processing. This type of indicators is the most time-consuming to process and accumulated in the learning process. The sources for manual collection of information include:

- attendance rates;
- grades in a traditional form, without of using e-learning systems (lectures, seminars, laboratory works, practical works).
- independence in work;
- creativity of work;
- assimilation of material;
- student motivation.
3. Collecting data of educational process

For a reasonable comparison of results such as results in automatic and automated modes, it is necessary to translate the results into a comparable form. This procedure is called as scaling.

If we need to bring the results to a comparable form, it should be used the scales of standard estimates obtained based on linear transformations of the Z-scale. To transfer the initial data to the Z-scale, it is necessary to perform a standardization operation, which consists: the arithmetic mean value is subtracted from each value of a certain indicator (this operation is called centering), the result is divided by the standard deviation value:

\[ Z_i = \frac{X_i - \bar{X}}{\sqrt{\frac{\sum_{j=1}^{n}(X_i - \bar{X})^2}{n-1}}} \]  

(1)

, where \( n \) – number of indicators in the sample. \( X_i \) – the value achieved by a particular student in terms of the indicator, which should be reduced to a comparable form. \( \bar{X} \) – average sample value.

In order to bring the values to a positive form, it is necessary to choose new values of the arithmetic mean \( M \) and standard deviation \( \sigma \). To convert the data, use the formula:

\[ z_i = M + \sigma_z \]  

(2)

, where \( M \) new arithmetic mean and \( \sigma \) – new standard deviation.

To translate z-ratings to a new form, we use a 100-point T-scale with \( M = 50 \) and \( \sigma = 10 \):

\[ T_i = 50 + 10z_i \]  

(3)

After converting the results to the T-scale, the results are obtained in a 100-point system, which must be converted to a standard 5-point rating system:

\[ T_i^{fn} = 5 - \frac{\text{max}(T) - T_i}{\text{max}(T) - \text{min}(T)} \cdot \frac{3}{3} \]  

(4)

As a result of performing transformations with the source data, we obtain a result that can be further processed and compared with other results achieved by students in the educational process.

4. Collecting data of educational process

A competency-based model of educational process involves using modern tools and technologies for monitoring the educational process. Information systems and technologies in the form of e-learning systems used to improve the quality of education, which include:

a) virtual computer laboratories (VCL) as a result of virtual dedicated server technology [2];

b) interactive forms of training (IFT) as a part of e-learning systems, integrated by SCORM/AICC/IMS;

c) distance learning systems (DLS) or learning management systems (LMS).

VCL are implemented by using specialized software, as well as in accordance with the principles of implementing cloud services based on DaaS (Desktop as a Service) technology. Data of the results of work, with this method of interaction with students (VCL), will be collected in automatic, automated and manual modes:

\[ VL_{auto} = \{VL_1, ..., VL_n\} \]
\[ VL_{atmz} = \{VL_{n+1}, ..., VL_m\} \]
\[ VL_{manual} = \{VL_{m+1}, ..., VL_k\} \]

\[ VL = VL_{auto} \cup VL_{atmz} \cup VL_{manual} = \{VL_1, ..., VL_k\} \]  

(5)

IFT are implemented by using separate software or using additional modules in the LMS. Lot of modern systems for creating interactive courses support standardized tools of implementing e-learning
courses. Using standards in the field of e-learning (SCORM, AICC, xAPI, Tiny Can), IFT are integrated into the LMS in such a way that they can transmit data on the results obtained as part of their work.

\[ IK_{auto} = \{IK_1, ..., IK_n\} \]
\[ IK_{atmz} = \{IK_{n+1}, ..., IK_m\} \]
\[ IK_{manual} = \{IK_{m+1}, ..., IK_k\} \]
\[ IK = IK_{auto} \cup IK_{atmz} \cup IK_{manual} = \{IK_1, ..., IK_k\} \]

As a semester coefficient OEL, we will use values based on data obtained in the automatic and automated modes when working with LMS as part of individual educational courses, and the system as a whole:

\[ EL_{auto} = \{EL_1, ..., EL_n\} \]
\[ EL_{atmz} = \{EL_{n+1}, ..., EL_m\} \]
\[ EL = EL_{auto} \cup EL_{atmz} = \{EL_1, ..., EL_m\} \]

The traditional educational process is the most time-consuming to collect and process educational data. The data obtained as a result of traditional lectures, seminars, laboratory work must be transferred to the EIEE for further processing:

\[ TS_{manual} = \{TS_1, ..., TS_n\} \]

5. Assessing competencies model

The above presented parts of supporting the educational process can solve the problem of collecting and storing data of the learning process. The use of the above educational information technologies allows solving various tasks of monitoring the educational process and managing the quality of students’ knowledge and abilities.

Having the values of individual performance indicators in virtual laboratories (VLj), interactive forms of training (IKj), learning management systems (ELj), traditional educational forms (TSj) it could be find generalized student performance indicators [2-3], with importance (Ij) of each indicators:

\[ OVL = \sum_{j=1}^{n} V_{Lj} I_j \sum_{k=1}^{m} I_k \]
\[ OIK = \sum_{j=1}^{n} I_{Kj} I_j \sum_{k=1}^{m} I_k \]
\[ OEL = \sum_{i=1}^{n} E_{Li} I_i \sum_{j=1}^{m} I_j \]
\[OTS = \sum_{i=1}^{n} T_{Si} I_i \sum_{j=1}^{m} I_j \]

where n, m – count of indicators.

Based on the formulas (9-12), it could be calculate the generalized performance indicator U:

\[ U = OTS \cdot I_{ots} + OEL \cdot I_{oel} + OVL \cdot I_{ovl} + OIK \cdot I_{oik}, \]
\[ I_{ots} + I_{oel} + I_{ovl} + I_{oik} = 1 \]

where I_{ots}, I_{oel}, I_{ovl}, I_{oik} – importance weight of corresponding values relative to each other.

Based on indicators about the educational process WS, that is calculated as importance of subject [4, 5], U, λ [3-4, 6], it can be received the final formula for the development of a certain competency Ks in the educational process:
\[ K_S[i] = \frac{\sum_{j=1}^{n} W_S[j] \cdot U_j \cdot \lambda_{exp}[j]}{\sum_{j=1}^{n} W_S[j] \cdot \lambda_{exp}[j]} \]  \hspace{1cm} (15)

where \( n \) – count of educational technologies which affect on competency.

\section*{6. Conclusion}

If we have a real representation of competency development indicators throughout the entire period of study, it gives us a possibility to make an in-depth analysis and forecasting regarding by a particular student or a group of students. The data which obtained because of monitoring allows to check how student developed (developing) competency and what subjects gave (or give) a greater or lesser effect. When it possible to possess relevant and objective information about the educational process, operational recommendations can be developed to improve the general level of knowledge and skills of students.

\section*{References}

[1] Efremova N F and Kazanovich V G 2010 \textit{Assessing the quality of training of students in the framework of the requirements of the Federal State Educational Standard of Higher Professional Education: the creation of a fund of assessment tools for student certification in the implementation of competency-oriented standards of the new generation: Installation organizational method. materials of the thematic seminar cycle.} (Moscow: Res.cent.of prob.qual.prep.spec)

[2] Belov M A, Lupanov P E, Tokareva N A and Cheremisina E N 2017 Concept of the improved architecture of virtual computer laboratory for effective training of specialists skilled in distributed information systems and design tools \textit{Mod.inf.tec.and IT-edu.} 1 182-9

[3] Cheremisina E N, Mitroshin P A and Belov M A 2013 Integrated E-Learning Systems as Tools for Assessing Students’ Competencies \textit{Sci.and bus.} 5(23) 113-22

[4] Mitroshin P A 2012 Methods of estimating competencies of students on the base of distance learning systems \textit{Inf.and edu.} 2(23) 24-8

[5] Saati T 1993 \textit{Decision-making. Method of the analysis of hierarchies} ed R Vachnadze (Moscow: Radio and communication)

[6] Bloom B S, Engelhart M D, Furst E J, Hill W H and Krathwohl D R 1956 \textit{Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain} (New York: David McKay Company)