Elaborating test materials for digital assessment of BSc students’ learning outcomes in training area "Agroengineering", profile "Electrical Equipment and Electrotechnology"

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Abstract. The paper considers modern specific features and requirements for engineering education. The authors show changes in the forms, methods and means of professional education. The main engineering activities are specified for training area "Agroengineering". The paper underlines the importance of the comprehensive development of future engineers' thinking, in particular, theoretical thinking, and the ability of performing logical actions with scientific concepts, using mental operations of comparison, concretizing, generalizing and abstraction. To check the development level of theoretical and logical thinking, the authors developed an educational and diagnostic test on the "Electrical Materials" course to note the necessity and possibilities of using computer testing for the strategic, systematic and objective assessment of students' knowledge, in terms of the development of their professional thinking and competencies. There is a description of the procedure of elaborating test materials, and the test results are presented. The authors analyze the digital test results at the stage of ongoing control and the number of mistakes that students made when performing tasks of different subtests and sections. Assumptions are made about the possible reasons for the poor outcomes; possible ways to improve the test procedure are offered.

1. Introduction
The development of science and technology, the change and complication of technological processes encourage engineers to constantly update and improve their knowledge, skills and abilities and acquire new ones. Constant technological innovations lead to the rapid obsolescence of any professional education [1]. The dynamics of growing demands for the engineering education quality and global socio-economic processes determine changes in training future engineers to increase its efficiency [2, 3, 4]. Engineering education, as well as any other modern training area, is actively transforming, acquiring stable features of a continuous process, and increasingly shifting towards blended learning. Blended learning combines the strengths of traditional and distance learning, contributing to the development of both social and information competencies [5].

Some authors note that blended learning based on electronic educational resources is rather promising as it offers new ways to use digital technologies in engineering education, the main task of
which is not only to increase the effectiveness of learning, but also to form students' professional, informational and self-educational competencies [6, 7].

Russian State Agrarian University – Moscow Timiryazev Agricultural Academy is training engineers in multidisciplinary area 35.03.06 "Agroengineering". An analysis of the engineering professions in the agricultural sector singles out two principal engineering components: agricultural mechanization and agricultural electrification. In accordance with this classification, Federal Educational and Methodological Association for Agriculture, Forestry and Fishery developed two exemplary basic educational programs: "Operation and Repair of Machinery and Equipment" and "Electrical Equipment and Electrical Technologies"; each having a set of variable components. The training of agricultural engineers, as farm power supply specialists, is of a dual nature. Students master courses and competencies related to electric power and electrical engineering; these courses making up more than a third of the curricula. And at the same time they master courses focused on agricultural production. While mastering the program, BSc students prepare for carrying out different professional activities, namely research, production and technology, organizational and management and project ones. Curricula for training BSc students in the area of agroengineering are focused on the development of universal general and specific professional competencies, the formation of a harmonious personality and a professional in the field of agricultural electrification [8].

The modern papers devoted to the analysis of Russian engineering education problems emphasize a decreasing level of applicants’ and engineering students’ knowledge. [9]. The study of the intellectual characteristics of engineering students conducted at Russian State Agrarian University – Moscow Timiryazev Agricultural Academy confirmed this opinion. Diagnostics of students’ intellectual characteristics showed that the results of the intelligence test (the Amthauer Intelligence Structure Test) are closer to the lower limit of the age norm [10]. The lowest ones were the indicators of the development of theoretical abilities, the ability to logically operate concepts. The most difficult task was to generalize a concept or determine its category.

Modern scientific psychology considers the process of generalization as the essential feature of human thinking. It is associated with the deepest reflection of reality and its intrinsic properties, connections and relationships. The formation of concepts requires knowledge of a set of corresponding object features, the specific synthesis of various generalization degrees, the ordering of all available features. The system of scientific concepts objectively reproduces significant aspects of reality. Conceptual structures are the basis for organizing all other forms of mental experience. One of the goals of engineering education is the formation of an integral figurative-procedural model of the aspect of objective reality associated with a professional's activity. The system of scientific concepts characterizing this model must offer prompt and correct solutions to professional problems. Insufficient development of the future engineers’ theoretical thinking and their inability to carry out mental operations of abstraction, concretizing, generalizing and classification with concepts that summarize the intrinsic characteristics of work objects become an obstacle to achieving success, first in study and professional activity, and then in independent professional practicing. Such features of the students’ cognitive abilities require constant monitoring of learning outcomes, special efforts to develop teaching effects which will allow eliminating the drawbacks and forming the necessary qualities of professional thinking.

Russian educational institutions use three main types of control: ongoing, intermediate, final (state certification); each type of control being regulated by an institution regulatory local documentation.

The final state certification is the final stage of training. It can be the defense of a final qualification paper and a state exam, at educational organization discretion.

Intermediate control is carried out in the form of tests (pass or fail), graded tests (four-point marking scale), exams, defense of a course paper or project, and presentation of a practical training report. Intermediate control is compulsory for every student of the University; all the results being recorded in the appropriate files.

Ongoing control is carried out for all types of study activities: when offering courses (modules) and all types of practical training, as well as conducting research. It is carried out in a form determined by
the lecturer responsible for the definite type of activity. All test materials are reflected in the assessment materials of the course. In addition, ongoing control for each course is carried out during the test week, approximately in the middle of the semester; intermediate results of each student are recorded in the files of ongoing control. Being one of the elements for assessing students’ mastering of syllabi content, it enables the monitoring of study activities and encourages students’ conscious attitude to the study process and learning outcomes. For a qualitative assessment, it is necessary to comply with certain requirements for ongoing control: it must be systematic and regular; test materials should be diverse and aimed at diagnosing different abilities; the uniformity of the requirements of the teaching staff for all students must be observed; test materials should be elaborated in such a way as to minimize the subjective conclusions of the examiner.

Russian State Agrarian University – Moscow Timiryazev Agricultural Academy approved the procedure for monitoring students’ progress in the main (bachelor, specialist and master) professional curricula of higher education. This practice is legally based on Federal Law No. 273-FZ of December 29, 2012 “On Education in the Russian Federation” (approved by the order of the Ministry of Education and Science of the Russian Federation dated 19.12.2013, No. 1367), the Charter and local regulations of the University.

At present, when there is an urgent need for remote assessment of the formation of students' competencies, many universities have approved local documents regulating the procedure for organizing and conducting test procedures to assess knowledge, skills and abilities. So, Russian State Agrarian University – Moscow Timiryazev Agricultural Academy approved the Regulation on the specifics of students’ intermediate control in the bachelor, specialist and master curricula of higher professional education using e-learning and distance learning technologies.

The regulation reflects the procedure for organizing and conducting all types of intermediate control, the procedure for conducting recurrent intermediate control in a distance mode, however, the content of test materials is not regulated and they are fully developed by the lecturer independently. This introduces elements of subjectivity in the assessment of the knowledge level and the degree of competence development.

The digitalization of the training process provides for new opportunities for continuous monitoring students’ learning outcomes, analysing the dynamics in forming professional abilities, assessing the features of their structure and qualities. This factor provides for systematic and purposeful supervision of the development of thinking while training engineers.

2. Study goal
The above described concept defined the study goal. Using the electronic educational environment, the authors decided to develop a monitoring procedure for the "Electrical Materials" course, aimed at objective assessment of knowledge, while stimulating the conceptual theoretical thinking of future engineers and identifying gaps in knowledge and insufficient mental operations.

3. Research methods
The "Electrical Materials" course is compulsory in the basic curriculum part. This course precedes other highly specialized professional subjects. As a result of its study, students develop some general professional competences, which imply:

- knowledge of the basic laws of electrical engineering, physical quantities, constants, their definition, meaning, methods and units of their measurement, types of electrical materials, their main properties and features;
- the ability to correctly understand and explain physical laws, phenomena and properties, to use modern electrical materials, and problem solving skills using the basic laws of electrical engineering;
- practical skills in analyzing, designing and installing electrical equipment in agricultural production, taking into account the basic properties of electrical materials.
To achieve the study goal, we found it necessary to highlight the invariant content of the course, to design a system of concepts that determine the success of solving study and professional tasks, to develop tasks, and to test the monitoring procedure. The study manual "Electrical Materials" [11] served as a source for the training and diagnostic test; the selection of concepts being carried out by the lectures of the course "Electrical Materials" course, based on the course syllabus. This course includes four sections: "Classification of Electrical Materials", "Conductive Materials", "Electrical Insulating Materials" and "Magnetic Materials".

The methodological basis for elaborating scaffolding tasks was the activity approach, which proved that objects are generalized only according to recommended sequence of the subject's activities related to these objects [12]. Tasks for determining the type of logical relations between the academic subject concepts, analogy-based activities, deductive and inductive inferences should stimulate theoretical thinking, while clarifying the logical structure of scientific and academic concepts.

Testing was carried out on the onlinetestpad.com platform. Test settings allow adapting (programming) the procedure for its implementation to specific diagnostic or training tasks. The main settings provide for mixing questions, answer options, limiting the time for passing the test, prohibiting / allowing copying the text of the question to the clipboard, changing the answer after confirmation, and so on.

Forty-four first and second year students of Institute of Mechanical and Power Engineering named after V.P. Goryachkin (Russian State Agrarian University – Moscow Timiryazev Agricultural Academy), majoring in area 35.03.06 "Agroengineering", took part in testing. It was carried out in two sessions. The first session took place after studying Sections 1 and 2. The second block of tasks, which includes Sections 3 and 4, was offered when the students were completing the course "Electrical Materials".

4. Results
Two blocks of test tasks were formed. The first included the content of Sections 1 and 2, the second covered Sections 3 and 4. During the first testing, the lecturer provided the students with the hotlink to the tests posted on the onlinetestpad.com platform. But not all students turned out to be ready for independent work without the lecturer's external control. Consequently, the process of presenting assignments needs improving.

To increase the reliability of the remotely-obtained data, a testing procedure was developed, which ensured independent performance of assignments by the students. It consisted of 5 stages.

At Stage 1 the students’ presence and their readiness to perform tests online were checked.

At Stage 2 presented typical instructions for proper performance of the tasks offered.

At Stage 3, the hotlinks were consequently sent for taking the subtests (each subsequent hotlink was sent to the student 2-3 minutes before the end of the scheduled time for taking the previous subtest).

At Stage 4, the students were registered as test takers on the subtest page. The IP address of the test taker was determined automatically.

At Stage 5, at the end of each subtest, the students were presented the results as a column graph of correct answers and a verbal interpretation of quantitative indicators. 50-60% of correct answers constituted a satisfactory result, 60-80% - good, 80-100% - excellent.

In addition, after the intermediate testing in the first two sections, the lecturer left the tasks in the public domain and regularly gave tasks to the students to work with individual test tasks to train their thinking abilities.

While elaborating learning tasks, the authors used various task modifications for diagnosing the thinking abilities of schoolchildren, applicants and students. Each block consisted of four subtests: "General awareness" - 20 tasks, "Analogies" - 20 tasks, "Odd-one-out" - 20 tasks, "Problem Solving" - 10 tasks.

The subtest "General awareness" includes tasks that assess the quality of learning outcomes in the course. They represent traditional tasks for pedagogical diagnostics with the multiple choice of one correct answer. At the same time, the recommendations for elaborating this type of tasks were taken into
account; there were answers-distractors, elaborated to neutralize the manifestation of "common sense" and resourcefulness of an unprepared student. The task itself was a definition of one of the studied concepts. The subtest "Analogies" provides tasks for identifying the type of logical relations between concepts and performing actions by analogy. When elaborating the tasks, the relations "genus-species", "part-whole", "opposites", "functions", "cause-effect" were used. The third type of tasks involved selecting one of five concepts, which cannot be attributed to a more general category that unites the other four concepts. Subtest 4 checked the knowledge of formulas and the analysis methods [13]. Table 1 presents the distribution of assignments of different types by the course sections.

### Table 1. Matrix of distribution of test tasks and percentage of wrong answers.

| Course sections                  | Number of tasks per section | Number of subtest tasks | % of wrong answers |
|----------------------------------|-----------------------------|-------------------------|-------------------|
| «Classification of Electrical Materials» | 23                          | 9                       | 32                |
| «Conducting Materials»            | 47                          | 11                      | 39                |
| «Electrical Insulating Materials» | 48                          | 10                      | 19                |
| «Magnetic Materials»              | 22                          | 10                      | 12                |
| % of wrong answers               | 25                          | 40                      | 47                | 21                |

The number of tasks for the sections is not the same, since the number of academic hours for these sections also differs. Thus, for Section 3 "Electrical Insulating Materials" 26 academic hours are planned, and for Section 4 "Magnetic Materials" - eight academic hours. This is due to the fact that the study of magnetic materials within the course "Electrical Materials" is only for informational purposes and serves to learn concepts of these substances, their structure and properties, and will be continued in subsequent courses. The number of tasks for subtests also varies. This correlates with the specifics of the test tasks, with the focus of a specific subtest, the usefulness of its tasks for the development of significant qualities of a future engineer’s thinking.

The last column and the last row of table 1 present data on the number of mistakes made by students when completing assignments on various sections and subtests. Diagnostics and analysis of the number of mistakes for individual subtests showed that the students coped most successfully with problem solving. The subtest "Problem solving" allows the students to show themselves and the lecturer their ability to apply new knowledge in solving study problems. They also completed the "General awareness" subtest quite well. These tasks include definitions of basic concepts, reveal the factual knowledge, and demonstrate the success or failure of mastering this knowledge. Many more mistakes were made by the students in assignments that involve performing actions by analogy and classification. The "Analogy" subtest diagnoses and forms the students' skills to identify logical connections between concepts. Tasks of the subtest "Odd-one-out" develop and show the students' abilities for reasoning, abstraction, generalizing and concretizing while operating with the main concepts.

Analysis of the number of mistakes by sections showed that the study of the second half of the course was more successful; the total percentage of wrong answers decreasing almost twice. This can be explained by the influence of learning exercises, which stimulated the development of the ability to operate with the studied concepts and reveal the logical relationship between them.
5. Conclusion
Thus, test materials were elaborated for digital assessment of the students' knowledge, a procedure was developed to obtain reliable data on the quality of mastering the course "Electrical Materials". The elaborated test tasks perform both diagnostic and learning functions. These tests require the lecturer and the students’ cooperation and feedback, various forms of presenting results, their quantitative and qualitative analysis. The digital environment, familiar and comfortable for modern students, in addition to facilitating the lecturer's work, performs teaching and learning functions, stimulates cognitive motivation [11], students' self-assessment and self-correction skills.
Further study is required to unify test materials for using in one university or training area.

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