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FORMATIVE ASSESSMENT OF A STUDENT'S LABORATORY WORK REPORT

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Abstract:
The article examines the methodological foundations for organizing and assessing physics laboratory classes. When evaluating laboratory work, indicators such as students' preparedness, work process, measurement accuracy, result analysis, and report quality are taken into account. Based on formative assessment and collaborative learning technologies, the effectiveness of laboratory classes in enhancing students' experimental knowledge and learning outcomes is demonstrated.

Keywords: Laboratory classes, physics education, laboratory work assessment, evaluation criteria, formative assessment, collaborative learning, experimental skills.

Introduction

Аннотация. В статье рассматриваются методические основы организации и оценки лабораторных занятий по физике. При оценивании лабораторных работ учитываются такие показатели, как подготовленность учащихся, ход работы, точность измерений, анализ результатов и качество отчета. На основе формирующего оценивания и технологий совместного обучения показана эффективность лабораторных занятий в повышении экспериментальных знаний и успешности усвоения материала учащимися.
Ключевие слова: лабораторные занятия, преподавание физики, оценка лабораторных работ, критерии оценки, формирующее оценивание, совместное обучение, экспериментальные навыки.

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Laboratory classes constitute an integral part of physics education. Through performing laboratory work, students test theoretical knowledge in practice and develop essential skills such as conducting experiments, observation, and data analysis. The assessment of laboratory work differs to some extent from the evaluation of other types of learning tasks, as both the process and the outcome are of significant importance. Therefore, it is considered appropriate to develop specific assessment scales and criteria for laboratory work. In this context, the following question arises: according to which criteria should laboratory work be assessed? Typically, the assessment of each laboratory work focuses on the following key aspects;

Preparation for Laboratory Work and Level of Theoretical Understanding: Before commencing a laboratory experiment, a student must possess the necessary theoretical knowledge. To assess this, brief diagnostic questions are administered at the beginning of the laboratory session. For instance, prior to performing the experiment "Determination of Electric Charge Based on Faraday's Laws", a student should be familiar with the electrolysis process and the relevant formulas. Without this foundational knowledge, the student may not fully comprehend the experiment and, consequently, may perform it ineffectively;

Execution of the Procedure: A student is expected to correctly perform the practical procedure in accordance with the laboratory manual. This includes the proper operation of experimental equipment, adherence to the correct sequence of steps, and accurate use of required samples and measuring instruments. Compliance with safety rules is also essential. For example, in a physics experiment involving the assembly of an electric circuit, evaluation criteria may include whether the student correctly connects the instruments, assembles the circuit in an open state first, and follows other procedural actions accurately;

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Data Collection and Accuracy: During the laboratory work, a student's careful observation and precise recording of measurements are assessed. Laboratory experiments often require the use of measuring instruments such as thermometers, ammeters, voltmeters, rulers, or calipers. The student must maintain accuracy when using these instruments and record the results clearly and correctly. For instance, in the laboratory experiment "Refraction of Light in Different Media," the student measures the angles of incidence and refraction of light, as these measurements are critical for obtaining accurate results. Additionally, proper tabulation of the collected data and maintaining an organized record of observations are important evaluation criteria.

Data Analysis and Conclusion: The scientific value of a laboratory experiment is reflected in the student's ability to correctly analyze the obtained results. Evaluation criteria include the student's capacity to compare the observed results with theoretically expected values, provide scientifically grounded explanations for any discrepancies, and analyze potential sources of error. Additionally, the student's literacy and adherence to a scientific style in presenting the results are important factors in the assessment.

Quality of the Laboratory Report: At the conclusion of laboratory sessions, students submit a written report. The report should include the objective of the experiment, the obtained results presented in tabular and graphical forms, as well as analysis and conclusions. The significance of the laboratory report is twofold: first, it demonstrates the student's ability to present results in written form; second, it provides the instructor with an opportunity to assess the student's scientific literacy. Therefore, assessment criteria may include the structure of the report, clarity of writing, calculation accuracy, and correctness and completeness of graphs and tables. In many cases, laboratory reports completed according to formal requirements are evaluated using a five-point grading scale. (1-table).

1-Table Assessment Criteria for the Laboratory Report

The report is complete and logically organized	**5 points**

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The report includes the main results, but some minor deficiencies are present	**4 points**
The report contains significant deficiencies	**3 points**
The report does not meet the required objectives and is unclear	**2 points**

Taking into account the criteria presented in Table 1, instructors typically use an observation sheet to assess laboratory work. However, implementing a "Laboratory Notebook" instead of an observation sheet is considered more purposeful, as each student independently prepares a report for each experiment, and the instructor evaluates it based on the quality of its execution.
The laboratory manual for determining the density of objects with regular and irregular shapes is distributed in written form.

1. Determination of the Density of a Rectangular Parallelepiped Object.
The determination of the density of an object with a regular geometric shape is carried out in the following sequence [1, 2].
1. Measure the mass (m) of the parallelepiped object using a balance.
2. Measure the length (a), width (b), and height (h) of the parallelepiped base using a ruler.
3. Calculate the volume of the parallelepiped using the formula $V = a \cdot b \cdot h$.
4. Determine the density of the parallelepiped object using the $\rho = m/V$ formula and record its numerical value in table-2.
5. Enter both the measured and calculated results into the table.

2-Table Determination of the Density of Objects

Parallelepiped-shaped object	m, g	a, cm	b, cm	h, cm	V, cm^3	ρ, g/ cm^3
Wooden object						
Metal object						
Plastic object						

Required Equipment: balance, object of regular geometric shape, ruler.
Assessment Criterion: Each criterion is scored on a 1-point system (1, 0.5, and 0), allowing for a total score of 10 points.

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Assessment of preparation:

1. The student must be able to explain the concepts of mass, volume, and density, and state their corresponding units. Each quantity (mass, volume, and density) is assessed individually. This section is graded out of 3 points as follows: the student correctly explains and states the units – 1 point; the student explains with some errors – 0.5 points; the student is unable to explain – 0 points

Assessment of work procedures:

2. The student is able to measure the mass of an object using a balance. This part is graded out of 1 point as follows: performs the measurement completely independently – **1 point**; performs the measurement collaboratively **– 0.5 points**; unable to perform the measurement – **0 points**.
3. The student measures the geometric dimensions of the object using a ruler and calculates its volume (this should be recorded in written form). Each task is assessed separately. This part is graded out of 2 points as follows: performs the measurements and calculations completely independently **– 1 point**; performs them collaboratively **– 0.5 points**; unable to perform – **0 points**.
4. The student has performed the calculations to determine the density of the object. This part is graded out of 1 point as follows: calculations are performed completely correctly – 1 point; minor errors are made – 0.5 points; calculations are incorrect – 0 points.
5. The results are recorded in a table, calculations are done in written form, and written answers are provided for the questions. Each task is assessed separately. This part is graded out of 3 points as follows: the task is fully completed – 1 point; the task is completed with some deficiencies – 0.5 points; the task is not completed at all – 0 points.

During our pedagogical study, students' learning outcomes were assessed using the widely applied 5-point grading scale. A total of 127 students from two schools in the Tashkent region participated in this study. The students were divided into experimental and control classes. In the experimental classes, additional tasks aimed at enhancing students' experimental knowledge were

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assigned during the lessons. As a result, an approximate 9% improvement in learning outcomes was observed.

In assessing the preparation and performance processes described above, we relied on formative assessment methods. Formative assessment is crucial for identifying students' strengths and weaknesses during the learning process, including the completion of laboratory work. Below, we outline the key aspects that a teacher should pay attention to when evaluating laboratory work:

- assessment should be systematic. If the assessment criteria and requirements are defined consistently across all laboratory works, students become accustomed to these principles and understand what aspects to focus on each time.
- assessment should be individualized. Each student must receive a grade for their own work in the laboratory. Even when tasks are performed in groups, it is recommended that the teacher circulates during the lesson, observes each student's work, and records their performance in the assessment document.
- assessment should be standards-based. Laboratory works must be structured and assessed in accordance with the required mastery levels as specified by the State Educational Standards (SES). This ensures that students achieve the intended learning outcomes. For example, if the physics curriculum within the SES specifies the study of "the classification of physical quantities, their units of measurement, and measurement methods," the laboratory work should lead to this learning outcome, which should then be reflected in the assessment.

When assessing laboratory work, the formative approach should not be overlooked. That is, the teacher should not limit themselves to assigning a grade only, but should also work collaboratively with the student by providing feedback on their performance, pointing out mistakes, and suggesting ways to improve. For example: "Today, when measuring the Archimedes' force, you made an error because the object was not fully submerged in water, which led to an incorrect result on your first attempt. Next time, ensure that the object is completely immersed in the liquid while recording the dynamometer reading, but without touching the bottom of the container." Such feedback is extremely valuable for the student, as it allows them to learn from their mistakes and

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perform more accurately and confidently in the future. Collaborative learning plays a crucial role in achieving these positive outcomes, and it is widely supported in modern educational practices worldwide. [3, 4, 5, 6].

Pedagogical research was conducted in general secondary schools in the Tashkent, Samarkand, and Namangan regions of Uzbekistan on the topic "Determination of the Density of Objects of Various Shapes" using collaborative learning technology in laboratory work. The students were divided into experimental and control classes. Collaborative learning methods were applied in the experimental groups. During the pedagogical study, unlike the widely used 5-point grading scale, these criteria were applied across all classes to assess students' learning outcomes: reproductive, productive, and creative. The study demonstrated a 12% improvement in students' learning effectiveness [7]. The assessment criteria used to evaluate learning outcomes were reproductive, productive, and creative, as presented in table -3.

3-Table Final learning outcomes

Final learning outcomes Reproductive	Final learning outcomes Productive	Final learning outcomes Kreative
Knows the equipment required to determine density (balance, ruler, graduated cylinder)	Can distinguish the equipment used for determining density (balance, ruler, caliper, graduated cylinder, hydrometer).	Can correctly use the equipment for determining density (balance, ruler, caliper, graduated cylinder, hydrometer).
Can name the instruments used to measure mass and volume (balance, ruler)	Can measure mass and volume and represent the results in a table.	Can apply the knowledge and skills for measuring mass and volume in real-life situations.
Knows and can state the formula for calculating density	**Calculates the density of an object based on the measurement results and draws conclusions.**	Has mastered the method for determining the density of objects of various shapes; can consciously explain the reasons for differences in measurement results and draw reasoned conclusions.

Conclusion

Laboratory sessions play a crucial role in reinforcing students' theoretical knowledge through practical application, as well as in developing their observation and analytical skills. In the process of assessing laboratory work, special attention should be given to preparation, the work process, data

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collection, analysis of results, and the quality of the report. The assessment system should be systematic, individualized, and standards-based, while also incorporating a formative approach that helps identify students' strengths and weaknesses. Experiments and pedagogical research have shown that the effective organization of laboratory work enhances students' experimental knowledge, and that collaborative learning significantly improves learning outcomes.

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