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ELECTRONIC ASSESSMENT OF LEARNING OUTCOMES OF EDUCATION SEEKERS

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Abstract:

Relevance: The relentless advancement of high technologies in society and education, in particular, has shifted traditional learning formats. The pandemic and military conflicts have compelled teachers to transition the educational process to a remote format, necessitating new approaches to testing and assessing learning outcomes using electronic technologies widely applied in distance and blended learning. Scientific interest has been sparked by mobile learning, which represents a new phase in the educational process, taking into account various contexts through social and content interaction with the use of personal electronic devices. Consequently, there is an urgent need to rethink the existing paradigm of learning and assessment.

Objective: To substantiate approaches to the implementation of electronic assessment of learning outcomes for education seekers, drawing on international experience.

Methods: Theoretical analysis of scientific and methodological literature related to the research problem; comparison, systematization, and generalization of data to synthesize theoretical materials and clarify the study's foundational concepts; empirical observations and modeling of educational situations.

Results: In electronic learning, a distinctive feature is the continuous process of assessing its outcomes, where information and communication technologies are utilized for the rapid transmission of respondents' answers. This process encompasses diagnostic (assesses the presence of subject knowledge; shows results; does not provide feedback; is not value-based; is not individualized), formative (evaluates the learning process; is always positive; is individualized; is value-based; provides feedback), and summative (evaluates learning outcomes; delivers a judgmental assessment; is applied according to standards; highlights shortcomings) assessment functions, which depend on the stages of learning at which the assessment takes place.

Conclusions: The primary obstacles to the development of electronic assessment on a large scale within an educational institution for any subject are time and the training of teaching staff. Additional challenges relate to software for electronic assessment, including compatibility with existing systems, scalability, performance, security, and limitations arising from updates, maintenance, and support. Electronic assessment is highly dependent on technological systems and tools.

Keywords: *assessment of learning outcomes, electronic assessment, testing, objectivity, distance education, general secondary education.*

Introduction. The continuous application of modern high technologies in education has enabled the development of more effective methods for testing and assessing learning outcomes through the use of electronic technologies. These technologies are widely implemented in distance and blended learning formats. Among the high technologies with widespread use are mobile devices, which include phones and tablets—currently the most prevalent digital technologies. According to an analytical study conducted by the Pew Research Center (2019), 96% of adults in economically developed countries own mobile phones, while 52% own tablet computers. It should be noted that these figures are increasing annually by an average of 2 to 5 percent. This rapid proliferation of mobile technologies is striking, especially when compared to the declining trend in ownership of desktop and laptop computers, which, according to the latest Pew Research Center survey, has dropped to 73 percent. A significant factor in this context is screen time, with children aged eight and older spending an average of 2-3 hours per day using digital technologies. The proportion of this time spent on mobile devices has tripled since 2011,

rising from 15 to 48 minutes per day (Lutze & Waldhör, 2015).

Given the rapid growth of mobile technologies, there is increasing scientific interest in mobile learning. This approach represents a new stage in the educational process, taking into account various contexts through social and content interaction, facilitated by personal electronic devices. Consequently, it is worth noting that students in general secondary education increasingly use computers and smartphones. As a result, educational institutions are striving to modify and develop electronic learning and assessment systems that effectively leverage these technologies. It should be highlighted that, as of 2014 (Arthur et al., 2014), electronic assessment was less widespread.

Today, the use of electronic devices for assessment in Ukraine is developing at an exceptionally rapid pace, largely driven by the COVID-19 pandemic and Russia's war against Ukraine. These factors have served as a catalyst for shifting from traditional classroom-based learning to distance, blended, and external study formats, significantly emphasizing the challenge of assessing the knowledge of general secondary education students. Mobile devices not only provide an environment for delivering personalized and context-oriented learning but also facilitate assessment anytime and anywhere. With the growing adoption of the "bring your own device" (BYOD) practice, electronic device-based assessment in education has emerged as a new direction within the context of research on distance and blended learning.

Previous Research. Due to the rising interest in electronic assessment of learning outcomes and its application in educational practice, there is a growing need to study and substantiate the equivalence of electronic and paper-based assessments. Scientific literature identifies three categories of research related to electronic (distance/electronic) assessment. The first focuses on using electronic assessment as a means of preventing online cheating during knowledge evaluation. The second pertains to the ergonomics of using modern electronic assessment systems. The third addresses limitations in studies that affect the equivalence of assessments. Given the theoretical nature of our research, we consider it appropriate to comprehensively examine the first and second research directions.

When exploring the challenges of classical and neoclassical approaches to assessment, it is relevant to focus on specific studies. Notably, Alan D. Mead and Fritz Drasgow (1993) sought to establish the equivalence of paper-based and computer-based tests through testing methods. Their findings indicated no significant difference between paper and computer-based assessments of learning outcomes. Furthermore, the authors found no evidence of an adaptability effect. This suggests that verbal and quantitative abilities measured through electronic assessment are equivalent to those evaluated via paper tests (Salgado & Moscoso, 2003). Nevertheless, concerns persist regarding the administration of electronic testing processes (Potosky & Bobko, 2004). In this context, issues related to the use of electronic devices during assessments have been highlighted (Arthur et al., 2014). As a result, many researchers and practitioners have expressed reservations about employing electronic devices in the assessment process (Ryan & Ployhart, 2014).

It is worth noting that Winfred Arthur Jr. et al. (2014) conducted a similar study with a sample of 69,000 individuals. Their research found that, overall, results were similar for electronic and non-electronic devices, and measurement invariance also pointed to equivalence between electronic and traditional assessments. However, scores on general mental ability tests were significantly lower when electronic devices were used. This led to a logical follow-up study examining the impact of electronic device characteristics—such as reduced screen size, portability, and varying internet connection speeds—on test performance (Tippins, 2015). Similarly, Matthew S. Castillo and Raymond Doe (2017) compared electronic and traditional assessments in terms of performance outcomes. Their experiment established that mobile-based assessment yielded results comparable to those conducted using personal computers or laptops.

Scientific interest also lies in differences between paper-based and remote exam formats, as explored by Cherry G. et al. (2021). This study involved 14,097 respondents. The researchers found no evidence to suggest that respondents performed or behaved differently across testing

modes. Additionally, there were no indications that individuals using their own devices for assessment differed significantly from those taking exams in a traditional format. The researchers emphasized the importance of providing respondents with clear instructions prior to assessment. Despite these studies, the issue of objective evaluation during electronic testing remains unresolved.

For a comprehensive understanding of mobile assessment effectiveness, the findings of a review study by Stavros N. and Economides A. (2018) are noteworthy. The authors analyzed 43 articles on mobile assessment published in seven leading educational technology research journals from January 2009 to February 2018. Key conclusions indicate that most mobile assessment studies focus on formative assessment of primary school students and STEM subjects (science, technology, engineering, and mathematics). The majority of the analyzed articles report a significant positive impact on student performance, motivation, and attitudes toward learning.

Purpose of the Article. The purpose of this article is to substantiate approaches to implementing electronic assessment of learning outcomes for education seekers, drawing on international experience.

Methods. The study employs theoretical analysis of scientific and methodological literature related to the research problem; comparison, systematization, and generalization of data to synthesize theoretical materials and clarify the study's core concepts; as well as empirical observations and modeling of educational situations.

Results and Discussion. From a definitional standpoint, mobile learning manifests in various contexts, encompassing both social and content interactions facilitated by the use of personal electronic devices (Crompton, 2013). On the other hand, it represents a departure from traditional pedagogy—that is, "sedentary" teacher-centered learning confined to a single location (Merchant, 2012)—as well as from stationary, classical approaches and outdated technologies. It is worth noting that connectivity during learning is the primary purpose of mobile devices, enabling students to communicate with peers, instructors, and other stakeholders, and to interact with content (i.e., consume, edit, and create) without spatial or temporal constraints (Crompton, 2013).

To integrate mobile learning theory with theories of both formal and informal learning, the theory of informal learning must be expanded to encompass both formal and informal pedagogies and learning processes that may occur in either formal or informal contexts. This will require a significant amount of research into learning processes occurring in informal settings, where mobile devices can serve as tools for such investigation (Lee, Fischback, & Cain, 2019; Xie, Heddy, & Vongkulluksn, 2019). Setting aside formal learning in formal contexts (e.g., classroom lectures), mobile learning theory provides a framework through which one can envision formal learning in informal contexts (e.g., watching a video lecture on a bus), informal learning in informal contexts (e.g., learning social interaction norms through team-based game lessons), and informal learning in formal contexts (e.g., through computer-supported collaborative learning). Typically, research grounded in psychological theories of informal learning does not account for these distinctions, focusing predominantly on autonomous, self-directed, or self-regulated learning, or on sociocultural and situated perspectives of learning and legitimate peripheral participation (Lave & Wenger, 1991; Zimmerman, 2013). Undoubtedly, these ways of conceptualizing learning are relevant to mobile learning research, particularly in understanding how to help students use mobile technologies more purposefully and effectively. Nevertheless, integrating mobile learning theory into psychological theories of learning will also broaden the understanding of informal learning, moving beyond its definition as merely the opposite of formal contexts and toward a more comprehensive conceptualization of the rules and constraints of formal and informal pedagogies and environments interacting with one another (Khaddage, Müller, & Flintoff, 2016). Similarly, the engagement often assumed in studies and theories of informal learning encompasses multiple dimensions (e.g., cognitive, behavioral, motivational, emotional, or agentic) (Azevedo, 2015), which can and should be measured and understood to optimally leverage the opportunities of informal settings for mobile learning.

The process of mobile assessment relies on empirical data about students' learning outcomes to enhance its effectiveness and support personal development. Assessment is the process of analyzing useful and relevant data and information from various sources to gain insight into learners' understanding, knowledge, and conclusions drawn from the learning material. This process incorporates diagnostic, formative, and summative assessment functions, which depend on the stages of learning at which the assessment is conducted. Specifically, the diagnostic function serves as a preliminary test to evaluate the current knowledge level of education seekers before engaging with the learning material, ensuring that educational activities align with their needs and requirements (see Figure 1). The formative function involves summative assessment that marks the completion of studying the learning material, serving to summarize and evaluate the outcomes of subject mastery. The summative function, in contrast, entails continuous assessment, where education seekers undergo testing to track their learning curve and enhance their understanding of the studied material.

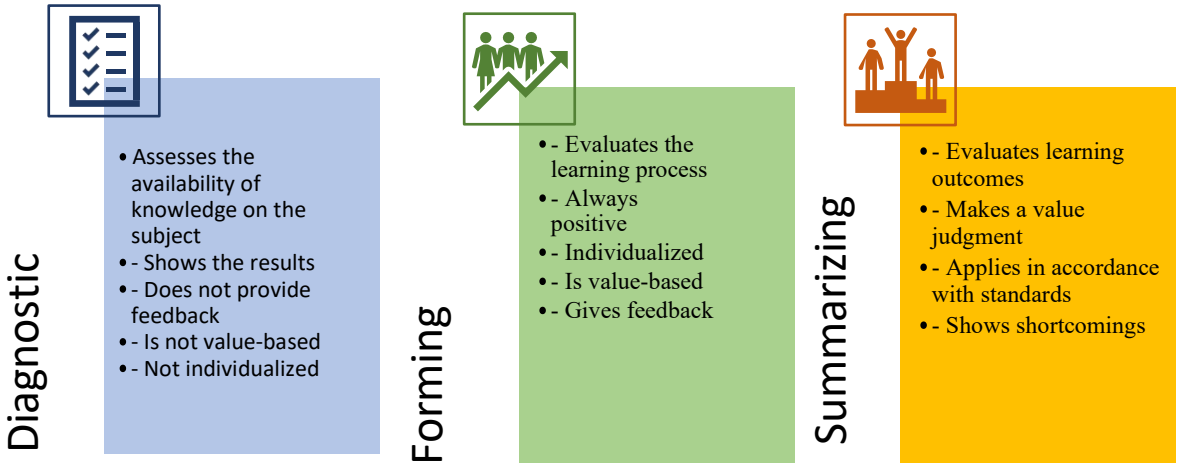

Fig. 1. Types of assessment

Let us note that diagnostic assessment is a systematic and rigorous process conducted at the beginning of the academic year in general secondary education institutions, at the start of studying a subject. Even an educational center can determine the best time to conduct diagnostic assessments for students (Self-Help Resources, n.d.). Thus, diagnostic assessment is essential for teachers to build a high-quality and productive educational process. Its primary task is to guide students toward better learning outcomes. Preparing for diagnostic assessment is a lengthy process that requires a significant amount of time to develop appropriate tools (tests, questions, practical tasks, etc.).

To conduct a high-quality diagnostic assessment among students, a teacher must consider: knowledge that directly impacts the goals of the diagnostic assessment; skills as the ability to perform specific actions based on the rational and purposeful use of previously acquired knowledge; and competencies as a set of knowledge related to the process of organizing and assimilating new educational information for students, as well as retaining and further applying it. Competencies during learning typically include mnemonics (Korol, 2020) (an approach to memorizing and recalling information), effective reading (Sluchyk, 2021), concentration techniques (Bremer, 2014), effective note-taking (Dron, 2022), and more. The purpose of diagnostic assessment is to help identify issues with a particular teaching style and provide insights into how teaching quality can be improved. Diagnostic assessment in education assists educators in understanding their students' strengths and weaknesses, as well as their level of knowledge and skills, even before the learning process begins. Examples of diagnostic assessments include preliminary tests that allow for an evaluation of students' knowledge (Harappa, 2021). During diagnostic assessments, tools such as journals, quizzes, tests, conferences, interviews, posters,

mind maps, gap-filling exercises, and surveys are utilized.

The advantages of diagnostic assessment include: providing teachers with information to create individualized educational trajectories for students; its informality and ease of use; the lack of a need for extensive preparation or standardized approaches that must be strictly followed; teachers' ability to refine or adjust their methods at any time; quick demonstration of results; and an easy way to share experiences with other teachers and colleagues. The disadvantages of diagnostic assessment include: the sequence of actions teachers must take during and after the assessment; reduced effectiveness as the number of respondents increases; the possibility that a teacher may make inaccurate assumptions about students' knowledge of a subject and overlook it during lessons; students unfamiliar with this type of assessment may experience anxiety and emotional distress; proper and reliable implementation may require specialized training; and the entire assessment process is time-consuming and demands significant teacher attention. With this in mind, diagnostic assessment is an important tool for teachers to obtain valuable empirical information that aids in better lesson planning, as well as for students to improve their learning outcomes.

The definition of "formative assessment" and its concept, related to the evaluation of educational programs during their development and testing, was introduced into academic discourse by M. Scriven (1967). Furthermore, the researcher defined assessment as a judgment made to rationalize weighted target objectives for obtaining a (relative) score. In turn, B. Bloom (1968) incorporated the learning process of students into the definition. He described formative assessment as an intervention in the learning process that enables the improvement of teaching and learning by clarifying to students which material they have mastered and which they still need to learn to achieve good results in summative assessments. Accordingly, formative assessment is used to gather information about students' understanding of the material throughout the learning process, helping teachers adjust the educational process as needed.

T. Fosnot (1989) notes that formative assessment is an approach based on constructivist learning theory, aimed at promoting effective and meaningful learning, which depends on what we already know; new ideas develop as we adapt and modify old ones. Learning based on interactions between students and other participants in the educational process cannot be evaluated using outcome-oriented assessments that prioritize how much students have learned rather than how they learn (Wang et al., 2010). It should be noted that learning occurs through students' interactions with one another and with teachers, and the active acquisition of knowledge by the student is the primary task of the educator. In this context, formative assessment, grounded in the principle of "assessment during and for learning," has gained significant importance in enhancing teaching quality. Formative assessment can be defined as "a process used by teachers and students to recognize and respond to learning outcomes in order to improve the quality of learning."

Fig. 2. Cycle of formative assessment (revised by the author

At the observation stage, difficulties in students' learning or conceptual errors in the material studied are identified. The clarification stage is characterized by helping to establish students' knowledge and skills. Teachers strive to determine what students know and what skills they possess, employing various approaches. These include diverse oral assessments or tests, concept maps, notebook checks, and more. Interpretation is the third stage of formative assessment, linked to organizing teaching based on students' needs. Consequently, teachers can adjust their instruction and planning to ensure students achieve an adequate level of knowledge and skills in line with the goals and knowledge outlined in the curriculum.

Relevant in this context is a study by R. Black and D. Wiliam (2009), where the authors identify five key strategies of the formative assessment process:

Organizing effective discussions, questions, and learning tasks that provide initial insights into the assimilation of educational material;

Providing feedback from the teacher that encourages students to develop and explore further;

Thoroughly explaining the educational material and conditions for success;

Stimulating students' motivation for extracurricular self-education;

Activating students as learning resources for one another.

It should be noted that all these strategies involve three parties: the teacher, the student, and peers. Although perceived from three perspectives, they all contribute to the development of the learner and the learning process.

In this regard, formative assessment impacts all students equally, yet it yields significantly better results for those with weaker preparation, directly contributing to an overall increase in the academic success of the learning group. Therefore, continuous formative assessment is a vital practice, as struggling students gain the opportunity to act on the feedback received, motivating them toward more effective learning.

Considering this, it is essential to understand the difference between formative and summative assessment. The results of formative assessment are comparatively higher, and its value is more significant for further learning. At the same time, summative assessment serves as a process of validating acquired knowledge. Although formative and summative assessments pursue different goals, their synergy can be asserted as a means of supporting students' learning.

Summative assessment is used to measure students' knowledge after a subject has been studied. This implies that during the assessment process, performance indicators for students are established. On the other hand, when it comes to validation, the entire learning process is considered—from setting goals to determining the level of achievement. R. Daugherty (2010) defines summative assessment as aimed at achieving overarching objectives, though it may sometimes have developmental side effects. As a result, teachers and students can adapt further learning based on its outcomes. The form and approach to this assessment will reflect the need for performance data emerging during the evaluation of learning outcomes.

L. Kukhar and V. Serhiyenko (2010) describe this type of assessment as testing that encompasses test classification, processing of test results, features of using computer technologies in testing, and rules for designing test tasks. In their developed manual, they elaborate on the advantages of test-based control, such as objectivity, accuracy, equal conditions, and comprehensive material coverage. However, they also highlight drawbacks, including an element of chance, limited time for in-depth topic analysis, inability to assess creativity-related knowledge, and the lack of insight into the causes of knowledge gaps.

Summative assessment serves as the final evaluation of a complete learning cycle. Given the potential for further in-depth study of the material, it may take on characteristics of interim, modular, or even ongoing assessment (2020). As noted by V. Kramarenko and A. Vorozhbyt (2021), summative assessment is a type of evaluation used at the final stage of studying specific material to determine the level of its mastery.

The purpose of summative assessment is to evaluate the level of mastery of educational material and assign grades, thereby validating students' current achievements. Summative assessment enables the identification of students' performance data and provides information in

forms such as: a report on an individual student for other teachers in the same school, another school, or parents/guardians; a report on individual performance as part of the learning process leading to public recognition for the student; or a report on group performance to provide aggregated data that educational institution leaders can use to monitor operations.

Thematic summative assessment is conducted verbally based on diagnostic assignments. These assignments reflect students' academic progress and may be included in their portfolios. Final summative assessment is based on teacher observations, thematic evaluations, and portfolio materials. The results are recorded in the student's certificate of academic achievements. In addition to documented learning outcomes, teachers may include remarks they wish to share with parents. Thus, in the context of distance learning, teachers must adhere to the methodology of formative and summative assessment of learning outcomes to enhance the motivation of educational process participants (Bohdanets-Biloskalenko, 2022).

Summative assessment is conducted periodically to determine what students know and do not know. While many associate it solely with standardized tests, such as state assessments, its scope is much broader. At the institutional level, summative assessment serves as an accountability measure, typically part of the grading process. A key aspect of summative assessment is that it measures students' academic achievements at a specific point relative to educational standards. Although the information obtained from this type of assessment is valuable, it can only assist in evaluating certain aspects of the learning process. Since it occurs over extended periods—every few weeks, months, or annually—summative assessment serves as a tool to evaluate program effectiveness, infrastructure improvement goals, curriculum alignment, or student placement in specific programs. Consequently, summative assessment often occurs too late to provide classroom-level insights or allow teachers to adjust the learning process, making formative assessment essential for such purposes.

It is worth noting that all described types are effective for both traditional and electronic assessment. Several models of electronic assessment incorporate these evaluation types:

The Four-Process Architecture (Almond et al., 2002) should apply to any assessment involving task selection, presentation, response processing, and summarization. This model emphasizes feedback at the task level and final feedback, as they are critical for improving the learning process. It addresses the challenge of breaking down any assessment form into modules, simplifying complex tasks and providing a clear understanding of the relationships between structure and operational processes.

The Reference Framework (Wills et al., 2007) is a visual structure for categorizing and organizing objects and actions related to assessment in e-learning. Based on conceptual principles, this framework reveals an ontology used to model the evaluation of learning outcomes for a specific subject.

The Abstract Framework (AL-Smadi et al., 2009) adopts a service-oriented approach with support for standards and specifications. Service-oriented architectures allow for designing and developing modular, flexible assessment systems where components can be added, replaced, or removed. Even new systems can be built from a set of services. This approach enables e-assessment systems to easily share and exchange content. Tests, items, grades, and student information can be implemented as services reusable by other educational institutions or government bodies.

Integrated into LMS (2007): Learning modules are provided either as e-learning or blended learning through a learning management system (LMS). After completing the study of a specific topic, an assessment of knowledge is conducted. If students successfully master the topic and pass the test, they receive feedback confirming their success. If they fail the test, they are provided with constructive feedback and the opportunity to review the material and retake the assessment later.

Integrated (Kuo and Wu, 2013): This model considers the interconnection of components such as the purpose of assessment, construct, interest in the subject, type of test, tasks, and the scoring procedure.

Common to these models is the identification of specific forms of assessment, such as general or structural. In this regard, it is

important to identify the common baseline characteristics of assessment types and establish the relationship between the components of evaluating learning outcomes through scoring mechanisms and teacher feedback.

In the process of e-learning and assessment, the use of educational electronic resources such as Google Classroom, Moodle, Microsoft Office 365, and streaming services like Google Meet, Microsoft Teams, Zoom, and others has become highly relevant. It should be noted that adaptation to their use began with the onset of the COVID-19 pandemic, posing a significant challenge for both teachers and students. Currently, a wide range of tools for electronic assessment exists, including ExamOnline, Turnitin, Hot Potatoes, DigitalEd, Interact, GoConqr, Socrative, ProProfs, and QuestionPro.

Conclusions. The primary obstacles to the development of electronic assessment on a school-wide scale for any subject are time and teacher preparation. Additional challenges related to software for electronic assessment include compatibility with existing systems, scalability, performance, security, and limitations arising from updates, maintenance, and support. Electronic assessment heavily relies on technological systems and tools, and since these tools and question types are used to assess knowledge according to Bloom's Taxonomy levels (Bloom, 1956), their understanding and application by educators are essential. Most reviewed studies reported a positive impact on academic performance, motivation, and students' attitudes toward learning and subsequent assessment. Furthermore, research has identified several gaps in the literature on electronic assessment.

During e-learning, a continuous process of evaluating its outcomes is characteristic, with information and communication technologies enabling the rapid transmission of respondents' answers. This process incorporates diagnostic (assesses the presence of subject knowledge, shows results, provides no feedback, is not value-based, and is not individualized), formative (evaluates the learning process, is always positive, individualized, value-based, and provides feedback), and summative (evaluates learning outcomes, delivers a judgmental evaluation, is applied according to standards, and highlights shortcomings) assessment functions, which depend on the stages of learning at which the evaluation occurs.

The above indicates that educators, particularly teachers, must continually update their knowledge of e-learning and assessment. Their ability to adapt and master new teaching methods and tools is crucial to students' success.

The analysis conducted underscores the need for further research to explore issues and challenges related to the negative perception of mobile assessment, especially from teachers' perspectives. Additionally, a stronger connection between student motivation and various electronic assessment methods should be established. This study may serve as a valuable resource for teachers and researchers working in the field of electronic assessment.

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