

Studying Efficiency of Digital Technology Facilitated Assessment Techniques in Higher Education

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Abstract—This study examines the adoption of digital technology in academic assessment or e-assessment in higher education. The main focus of this research is to determine the impact of advanced digital technology on different assessment techniques such as formative assessment and summative assessment. The goal of this study is to critically evaluate the selection of different assessment methods using digital technology to enhance assessment for more effective learning. Given the increasing use of digital technology in the assessment of students' achievement in the learning process, this research is significant. Based on a literature review of different assessment techniques using technology, this study focuses on the formative and summative techniques of e-assessment. The paper offers an in-depth analysis of the innovative and creative use of digital technology in assessment. The findings of this research will enhance knowledge and in-depth understanding of using technology in assessment, especially in active learning environments, in higher academic institutions.

Keywords—E-assessment techniques, assessment for learning, assessment of learning, digital technology.

I. INTRODUCTION

USING digital technology in the learning process including assessments, which is an integral part of the learning process, has become more common in higher education [1]. Assessment plays an important role in effective instruction and in enhancing students' learning achievement. Applying innovative digital technologies can ensure better assessments that are more useful for instructors and beneficial for students [2]. The emerging digital technology has become an essential tool to promote authentic as well as meaningful and more efficient assessments. Consequently, the e-assessment in higher education is increasingly encouraged [3].

The e-assessment, which uses digital technology for automated assessment, is increasingly used in various disciplines in higher education [4]. Therefore, it is important to know about the assessment using technology that ensures understanding of efficient feedback to students, guarantees measured and reasonable evaluation and supports the knowledge necessary to help students succeed in fulfilling their learning objectives.

Understanding assessment techniques using digital technology is important as these can collect students' knowledge efficiently, cost-effectively, and accurately. E-assessment can have a significant impact on costs, students' performance measurement and inference on their achievement, etc. [5]. In addition, the emergence of artificial intelligence

makes the e-assessment significant for research [6].

In this context, the objective of this study is to examine the innovative digital technology that facilitated different assessment techniques, especially formative and summative assessments in the active learning process. The technology can be efficiently used for both summative and formative assessments [4]. The conditions and consequences of the relationship between summative and formative assessments are important to examine in more detail. Consequently, this study examines the effectiveness of those e-assessment methods. This study can increase knowledge of how technologies are being used in students' assessment, curriculum design, and development to achieve planned learning outcomes and student success [7].

II. RELATED WORKS

A. Engaging Students in Active Learning Applying Digital Technology

With the development of innovative digital technology, the higher education environment has begun to change [8]. Advanced innovative technologies such as learning management systems, apps, Web 2.0, social media, etc. are being used increasingly as instructional tools to enhance the implementation of learning objectives, especially in online classes in higher education institutions to improve students' learning process. To remain competitive in the academic environment, higher education institutions are emphasizing on greater integration of digital technology in the learning process [9].

With the increasingly rapid advancement of digital technology, using the most suitable tools to enhance effective learning and instruction is advantageous [10]. Different learning management systems such as Canvas, Blackboard, Angels, etc. with their user-friendly and interactive user interface design, operate as an effective learning portal that allows students and instructors to interact confidently. The many useful features, such as announcements, a discussion board for communications between instructor and students, assignments, quizzes, and exams, posting grades, zoom meetings, etc. are available in the e-learning platform. Also, the class materials such as syllabus, and lecture notes in the form of text, audio, and video presentations can be delivered to students. In the learning management systems instructors can monitor students' activities as the platforms include tools for

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student tracking, their direct participation, collaboration, and communication in the discussion board. They can also conduct students' learning assessments in different methods [11].

There are different online active learning strategies such as Massive Open Online Courses (MOOC), flipped learning, problem-based learning, Socratic questioning, critical thinking, reflective writing, etc. These active learning approaches can positively affect students' overall learning experience [12], [13]. The MOOC, whose motto is knowledge sharing, is a large-scale learning strategy where students and instructors develop an online community in the discussion board. The MOOC aimed at unlimited participation and open access for students in a mutually engaging educational environment. The flipped classroom, another student-centered in-depth active learning approach, leads the future classroom with its blended learning of online and offline lectures by allowing students to study anywhere at any time using digital technology. In this active learning approach, students voluntarily study in advance the basic concepts and knowledge necessary for learning. Later in the classroom, they learn through their own thinking and active participation, encouraged by their instructor, and interacting with instructors for cooperative learning [14]. Flipped learning refers to a blended learning environment where digital technologies are systematically integrated to support the traditional in-person learning environment with the learning activities in reverse order. Along with the flexible and individualized learning experience [12], [13], students in this learning environment get more class time for interactive student-centered activities that engage them in the learning process improving their higher-order thinking skills, which ultimately enhance their academic performance [8].

The rapid expansion of digital media with different modalities offers advanced technologies such as text, image, video, audio, data visualizations, touchscreen, etc. These innovative tools allow the application of multiple modalities to demonstrate students' learning achievement via assessments designed in different forms. Students' learning progress can be documented in various modes over different periods using digital technology [15].

B. Assessment in Learning Process

Assessment is a fundamental part of the learning process to advance students' knowledge [3]. With its central importance in education, assessment is a vital part of the learning process [16] that helps instructors determine if learning objectives are met [1]. Assessment, which is carried out to obtain information about students' learning outcomes [16], plays an enormous role in students' studying and learning [17]. Learning and assessment are so interwoven that neither can be comprehensive without the other [18]. Therefore, new opportunities for developing e-assessment practices in higher education need to be identified [15].

C. Defining e-Assessment

The advancement of online learning in higher education has led to the development of e-assessment [19]. Applying digital technology, different types of assessment can be developed

including multiple choice, true/false, selection/identification, reordering/rearranging, substitution/correction, completion, construction, presentation, etc. [5]. With the increasing use of advanced technology, the multiple-choice questions method of assessment has increased over time because of more significant student numbers. The online examination enables students to take tests from any place, and at convenient times in asynchronous online classes [3].

E-assessment is an assessment that uses digital technology in a complete assessment process, including designing assignments incorporating e-testing, e-portfolios, etc. [6]. E-assessment can be defined as the use of digital technology and tools to develop, deliver, store, or reporting of student assessment tasks, responses, grades, or feedback [20]. E-assessment refers to exercises through which students use digital technology for taking their exams or completing assignments. It serves as an effective, unbiased method for assessing students' level of knowledge, academic performance, and problem-solving skills [16]. Various terminologies such as e-exams, e-assessment, online assessment, computer-based assessment, technology-based assessment, computer-based exams, etc. are interchangeably used to refer to technology-assisted assessment [21].

The result of an assessment process can be a score or description of students' level of performance based on all different procedures such as observations, quizzes, interviews, tests, lab work, etc. [22]. E-assessment is any type of assessment that has an electronic component and incorporates one or more e-testing, e-portfolios, etc. [6]. Using technology, it is possible to design and develop flexible and customized assessments such as audio, text, or text-to-speech, visual magnification, focusing on specific parts of the test item, highlighting, presentation settings (color overlays, contrast), sign language, etc. for diverse students with different needs [23]. The e-assessment includes multimedia-based constructed responses, automatic question item generation, automated grading with statistical results, and reports accessible anytime in the e-assessment systems that allow automatic test corrections, automatic grading, and summary reports. More advanced e-assessment systems include on-demand testing, e-portfolios, student modeling, formative assessments supporting learner autonomy, and diagnostic assessments which are all formative, etc. are possible [18].

III. METHODOLOGY

The research in this study was conducted based on an extensive review of current literature on technology-facilitated assessment or e-assessment. Especially the effectiveness of assessment techniques such as summative assessment and formative assessments were reviewed. For that purpose, research articles, especially recently published in peer-reviewed journals and conference proceedings, have been collected from online libraries and Google Scholar. Articles were searched in online libraries using key terms such as e-assessment, summative assessment, formative assessment, digital technology in assessment, assessment for learning, assessment of learning, etc., that are related to this research topic. Source

literature utilized a wide array of methodologies, including survey analysis, field experiments, case studies, theoretical analysis, statistical analysis, literature analysis, and confirmatory factor analysis.

A collection of more than 50 articles with relevant topics was gathered and reviewed. Those articles were down to 45 articles based on a sampling of relevance to the research. Finally, 40 articles, published from 2014 to 2023, were systematically reviewed to fulfill the research purpose. This approach selected the studies that focus on e-assessment techniques. Target analysis data from the selected literature were compiled in tabular format for collective analysis. Tracked categories included study title, authors and date of publication, sample method, instruments used in the research, and subsequent research findings or contributions to the body of knowledge.

IV. RESULTS AND DISCUSSION

A. Assessment Techniques

Summative Assessment: One of the various functions of assessment in higher education is to measure students' final learning outcomes to ensure whether the student achieved an expected standard of expertise or not [10]. Summative assessment, which is used to make final judgments about students' academic performance [24], is generally applied for this purpose as a measure of students' learning [25]. Summative assessment summarizes the achievement of individual students at the end of the academic year or semester [26]. Summative assessment, which is the judgment of final learning [27], focuses on whether the planned learning objectives have been achieved or not, and whether the predefined criteria and standards or requirements are fulfilled to grant accreditation or certification [18]. Examples of summative assessments are final projects, final papers, final exams, portfolios, etc. that do not offer students the opportunity to improve performance based on feedback provided by their instructor.

Formative Assessment: Formative assessment is administered continuously, systematically, analytically, and directly to improve students' learning to make it more efficient [27]. This assessment technique warrants frequent, interactive assessments of students' learning achievements and recognizes their needs in the learning process, and adjusts instructional strategy appropriately [28]. The technique focuses on what learning is taking place, what is not being learned, and what to do about it [29]. Thus, the formative assessment aimed to assess the quality of students' performances to guide students to improve their learning skills [30].

This assessment technique assists the students in the form of feedback to enhance their learning performance addressing their needs. The interaction between instructor and students or among students in active learning allows students to receive feedback on their current level of learning [18]. Consequently, formative assessment is considered as the assessment for learning to support students learning until they achieve the planned learning objectives. For that purpose, this assessment technique is applied as a source of continuous feedback to improve instruction and learning [31].

Subsequently, formative assessment is considered as a form of learning process because this assessment technique is aimed at helping students' learning improvement with timely and informative feedback [32]. Some common approaches of formative e-assessment are multiple-choice tests with feedback, and allowing resubmission of writing assignments after initial correction with feedback reflecting the strengths and weaknesses of the paper highlighted [33]. More examples are 1) exercises as a review for exams, question and answer sessions, or class discussions, 2) in-class activities where students present their projects to get feedback from their instructor as well as peers, 3) reflective journals reviewed periodically by the instructor during the semester, 4) student's meeting between with instructor to discuss on performance and progress, etc. Evidence of students' knowledge and learning performance can be obtained through different activities such as group discussions, dialogue, reflective questions, and classroom activities with feedback provided [27].

B. Significance of Feedback in Assessment

Formative assessment is a process applied to provide necessary feedback on ongoing learning to develop students' achievement of planned learning objectives [25]. This assessment is a helpful technique in providing students feedback after evaluating their learning in progress [34], [35]. It's a tool to measure students' ongoing learning [36] emphasizing on *for learning* and providing feedback [10].

Feedback, the key element of formative assessment, supports students' learning achievement [37] and is important for effective learning [38]. Feedback provides information about the gap between students' actual level and the required level of learning [39]. The main foundation of formative assessment is the feedback provided to both instructor and student. The feedback helps students be aware of existing gaps in their learning level and learning objectives or outcomes. In addition, based on the feedback instructors may adjust their instructional strategy to meet students' learning needs. The adjusted strategy can encourage students to put forth more effort in their learning, which leads them to higher success [27].

Digital technology can facilitate considerable support in instruction and learning if applied in providing immediate feedback to improve students' learning performance [40]. To enhance students' learning achievement, immediate feedback is crucial [10]. The unique features of advanced digital technology can provide a medium that helps students receive feedback on their weaknesses and strengths in the learning content [18].

Formative assessment takes place during the learning process by giving appropriate feedback to help students learn. The purpose of formative assessment is to find the best solution for the student's learning process by modifying the instructional process if needed. It is a continuous multi-phase process that is carried out through regular interaction between instructor and students providing feedback for immediate action, and modifying instructional strategies to improve learning. In formative assessment, student's knowledge is formed by analyzing and internalizing instructors' feedback [22].

In the assessment for learning, the assessment provides

immediate feedback to the instructor and students about the students' status of learning material. This feedback is used by instructors to adjust lesson planning if needed. Feedback in formative assessment provides instructors a strong understanding of a student's learning level, and how to reach a planned learning objective goal. The feedback guides instructors and students through individualized instructional approaches that optimize student's learning. It helps individual students improve learning to attain higher levels of performance and to create new knowledge [7]. The feedback processes can be enhanced through creative uses of technology that constructively align with formative assessment [40].

C. Assessment for Learning vs. Assessment of Learning

As shown in Table I, formative assessment emphasizes the continuous learning needs of students based on their current achievement and adjusts the instructional-learning process accordingly. Thus, the formative assessment process contributes to students' learning progress and is often regarded as an *assessment for learning* [10]. Formative assessment or *assessment for learning* is considered as an integral part of students' learning process, their motivation, engagement, and higher levels of achievement. Timely feedback from instructors can enhance and expedite students' learning [32].

Formative assessment with providing feedback helps students improve their learning while summative assessment measures their final learning without any opportunity to improve the learning [28]. Summative assessment provides information that enables judgments of students' learning about intended learning outcomes. The formative assessment provides feedback to students for learning that enables the enhancement of learning quality [37]. In contrast with formative assessment, which focuses on students' improvement in learning performance, summative assessment highlights the final performance [24].

TABLE I
 FORMATIVE ASSESSMENT VS. SUMMATIVE ASSESSMENT

Formative Assessment	Summative Assessment
Assessment <i>for</i> learning	Assessment <i>of</i> learning
Help individual student to learn	Evaluate student's final learning performance
Identify gaps between planned learning outcomes and student's learning achievement for improvement	Evaluate gaps between planned learning outcomes and student's learning achievement for judgement
Provide continuous feedback on specific needs during the learning process	Provide no feedback of specific needs or final feedback, if any
Offer opportunities to improve learning based on feedback	No opportunity to improve learning
Ongoing evaluation of student performance throughout the learning period	Final evaluation of student's accomplishment at the end of the learning period

Both summative assessment and formative assessment are processes that make judgments based on set standards, goals, and criteria. In formative assessment, feedback indicates the existence of a gap between the level of learning and the planned learning objectives. The formative assessment indicates how the learning can be improved to reach the learning objectives.

The summative assessment stops at the judgment, rather than providing feedback for learning improvement [39].

The main factor that differentiates summative assessment and formative assessment is the purpose [24]. The ultimate goal of education is to help students become lifelong learners, not just evaluate them [41]. Therefore, assessment must be for learning, in addition to verifying what students finally learned at the end of the learning process [20], which summative assessment does [31]. *Assessment for learning* emphasizes students' progress that affects the subsequent instruction; whereas *assessments of learning* focus on making judgments on students' final achievement at the end of an instructional process [32].

Traditionally, summative assessment has played a dominant role in evaluating students' learning achievement. However, formative assessment is increasingly recognized as the assessment technique that helps students improve their learning by providing continuous feedback during the learning period [41]. Although relatively more focus is given to the summative assessment, the formative assessment is essential for progress in students' learning. It is important to create student-centered learning and assessment environments [31].

D. Combining e-Assessment Techniques

Research on assessment of students' learning supports technology-based assessment in learning processes. The application of advanced digital technology can help to develop advanced *Assessments for Learning* and enhance *Assessment of Learning* [7]. Using technology, formative e-assessment analyzes the progress of students' learning about previous attainment of learning outcomes, while summative e-assessment indicates students' overall accomplishments in final learning [42]. Although the formative e-assessment is considered highly complex because it integrates technology in the instructional and learning progress in the context of instructor-student interaction [31], digital technology can be efficiently used for both summative and formative assessment [4]. More effective assessment providing feedback using technology for learning can be achieved [10].

Research findings show that trends and advancements in digital technology have contributed to the use of technology for formative assessment, which allows collaborative as well as self-guided learning processes. Findings also show that summative assessment can be enhanced by utilizing technology, which can provide tools to potentially make assessment interactive [10], [26].

However, both assessments are vital to the effective learning process [1]. While formative assessment is ongoing judgment plus feedback aimed to close the gap between students' performance and planned learning outcome, all assessment ends with summative assessment [39]. According to [25], combining summative assessment and formative assessment in students' learning process can be referred to as summative-formative assessment [25]. Both formative and summative assessments using digital technology can be valuable in evaluating students' skills and knowledge enhancing their learning [10].

Formative assessment allows students to correct their mistakes, while summative assessment enables instructors to understand whether students achieved the planned learning objective effectively after a certain period. Therefore, after formative assessment that lets students know their shortcomings and how to improve their performance; instructors should engage in a summative assessment that focuses on whether expected learning outcomes have been achieved by the students [1].

The blending of both techniques can play a vital role in improving the learning process. Combining formative and summative assessments can lead to higher learning achievement than applying either formative or summative assessment separately. That is, the formative assessment is more helpful when used along with summative assessment or vice versa [43]. Thus, the *assessment of learning* (summative) can be transformed into an *assessment for learning* (formative), which is beneficial for students [10].

Formative e-assessment supports the iterative process of analyzing the progress of students' learning about their previous attainment of learning outcomes, while summative e-assessment offers evidence of students' overall accomplishments by assigning a value to their demonstrable achievements [42].

In [44], it is found that both formative and summative forms of assessments support the learning processes. The finding supports the literature that suggests a learning environment that provides feedback, guidance, scaffolding, and aligned with learning objectives, should be systematically integrated in the design of learning and practice. The results suggest that the formative e-assessment is a useful scaffolding tool for the summative e-assessment to support students in achieving the learning objectives [44].

E. Advantages of e-Assessments

Higher educational institutions strive to improve the efficacy of student learning, especially when dealing with large groups of students with a limited number of instructors [45]. E-assessment can increase the objectivity of the assessment process [16]. Advanced digital technology allows the creation of a cost-effective way to customize test items for diverse students with different levels of need [23].

E-assessment, which is increasingly widely used in higher education institutions, can be applied for self-training, providing speedy feedback to students in their grading for exams/assignments compared to the time-consuming manual assessment [4]. Technology can be used to deliver speedy feedback as well as create a sense of an individualized and nurturing relationship between instructor and students [10]. Also, using technology, random questions can be generated for each student individually to prevent students from copying from each other [3].

One of the major benefits of e-assessment is the automated scoring of assessment data with enhanced efficiency and accuracy. This process lowers the possibility of human error because no human being is involved in performing data entry, calculating raw scores or domain scores, transferring scores,

making score conversions, searching and locating lookup tables, etc. for assessment [7].

E-assessment has various advantages over the traditional paper-based exam as it can be administered on demand, and offers interactive tests virtually on a large number of students at the same time [6]. Thus, e-assessment can also reduce costs. Besides reducing costs, the flexibility, instant feedback, improved reliability of digital scoring, the potential for structured and unstructured learning environments, etc. are advantages of e-assessment [6].

V. CONCLUSION

The study examined the current scope of e-assessment, the probable efficacy, and challenges it brings in the formative and summative e-assessment, and compared the advantages and disadvantages of formative and summative assessment using technology. The study focuses on the areas where digital technologies offer particular benefits to assessment in response to the changing learning environment with technology in higher education. Consequently, the study analyzed the authentic e-assessment in active learning taught in asynchronous and synchronous online delivery methods, where students' interactive participation is required. The purpose of this analysis is to understand the potential that technology offers in improving assessment, especially summative and formative assessment in active learning. The study suggests that using technology is beneficial in both formative and summative assessment. A combination of summative and formative assessment is more effective for students' learning achievement than either formative or summative assessment separately.

To ensure effective e-assessment in higher education, a joint effort is needed that includes educators, students, and other stakeholders who are involved in curriculum development, and applying effective technology in assessments. This combined effort can increase efficiency and improve learning outcomes for students. In addition, collaboration among researchers, practitioners in industry, and policymakers is needed to ensure optimal utilization of the advantages of e-assessment facilitated by innovative digital technology [7].

The basic finding of this study is that the summative assessment and summative assessment - both assessment techniques can be used productively using technology. As the skills, attributes, and competencies are important for students to develop their career path, the useful and effective assessment for learning and of learning are vital. The feedback process in assessment for learning or formative assessment can be enhanced through creative uses of technology. Therefore, innovative digital technology must be constructively aligned with formative assessment and feedback. This study can increase knowledge of how technologies are being used in students' assessment, curriculum design, and development to achieve planned learning outcomes and student success.

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