

Implementation of Formative Assessment in Engineering Education

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ABSTRACT: Formative assessment is an assessment of student learning that aims to improve students' skills or understanding of certain course themes. Formative evaluations are often conducted in class, can be conducted anonymously, and are typically much more focused on certain abilities or knowledge. This article presents a comprehensive literature analysis on formative assessment in engineering education. As an integrated narrative review, this study's methodology included a systematic search, review, and writing of the literature in order to synthesize the important themes and conclusions of research in this field. The authors selected and reviewed the available literature using qualitative thematic criteria, focusing on the relationship between formative assessment and students' attitudes, FA and self-regulation skills, online formative evaluation, validity, reliability, and dishonesty of assessment, and engagement with critical learning processes. An increase in student involvement and centrality in the process as primary actors, as well as the building of a learning community, are among the cited benefits. According to the primary results, effective online formative assessment can generate a student- and assessment-centered emphasis through formative feedback and enhanced learner engagement with significant learning experiences. In the context of online formative assessment, it has been discovered that ongoing authentic assessment activities and interactive formative feedback are vital for overcoming validity and reliability concerns.

KEYWORDS: Formative assessment; online assessment; self-regulation skills; learning experiences; critical learning

1. Introduction

The evaluation method has evolved from assessing students' understanding by comparing their performance with that of others to organizing instructional tactics to improve teaching or learning. This evolution is also noticeable in literary assessment concepts. In addition to the traditional concept of assessment of learning, which aims to monitor the strengths and weaknesses of student learning, assessment of learning, which aims to enhance student learning, has become more important [1, 2]. Consequently, formative assessment (FA) as a

way of assessing learning occupies an important place in today's educational systems. FA is an assessment technique that originates from the constructivist learning paradigm. Figure 1 shows a practical paradigm for an assessment and evaluation system. Constructivist learning theory aims to promote effective and meaningful learning based on prior knowledge; new ideas emerge when old ones are transformed and adapted [3, 4]. Moreover, learning occurs through students' relationships with one another and their teachers, and the active acquisition of knowledge by students is of the utmost significance.

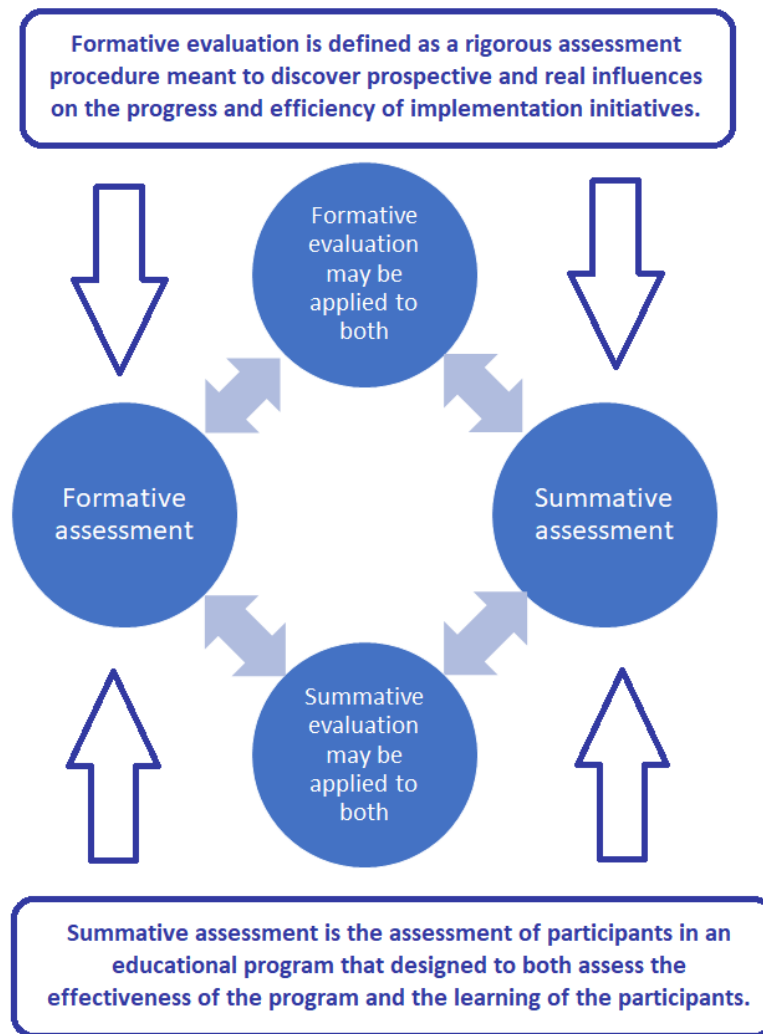


Figure 1. Practical model of assessment and evaluation system.

An outcome-based assessment strategy that places more emphasis on how much students learn than on how they learn would not be appropriate for assessing instruction that depends on students interacting with each other and actively engaging in the learning process. In this context, the approach FA, which is based on the principle of assessment of learning, has gained importance in improving the quality of education [5, 6]. FA is described as the mechanism that teachers and students use to recognize and respond to student learning in order to increase that learning within the learning process. FA allows both students and teachers to assess themselves in the classroom, which enables them to improve techniques, skills, and behaviors for more successful teaching [1, 2, 5]. In other words, FA reveals and applies student understanding to the learning process. In classrooms, two forms of FA are utilized. The first kind of FA, known as "informal FA," is comprised of in-the-moment classroom debates that lead to a consensus

on a topic. Without a set curriculum or instant, open-ended, discussion-based evaluation systems, teachers can decide whether or not their pupils have grasped a topic and then plan classes appropriately. Students' body language, gestures, and facial expressions provide teachers with additional feedback beyond the words they actually say. In contrast to IFA, the method used in formal FA is more scientific and unsubjective [5, 6]. Various methodologies and tools, such as concept maps and reflective diaries, are used to determine the degree of understanding of students. Teachers organize their lessons to improve students' comprehension based on the outcomes of assessments [7, 8]. Teachers can modify their instruction and lesson plans so that students attain a satisfactory level of knowledge and ability. In the classroom, appropriate teaching styles and approaches are also anticipated. After the instructional decision phase, this cycle recommences with the elicitation of student knowledge, followed by the pursuit of curriculum-based learning objectives [7–9]. The differences between summative assessment and formative assessment are shown in Figure 2.

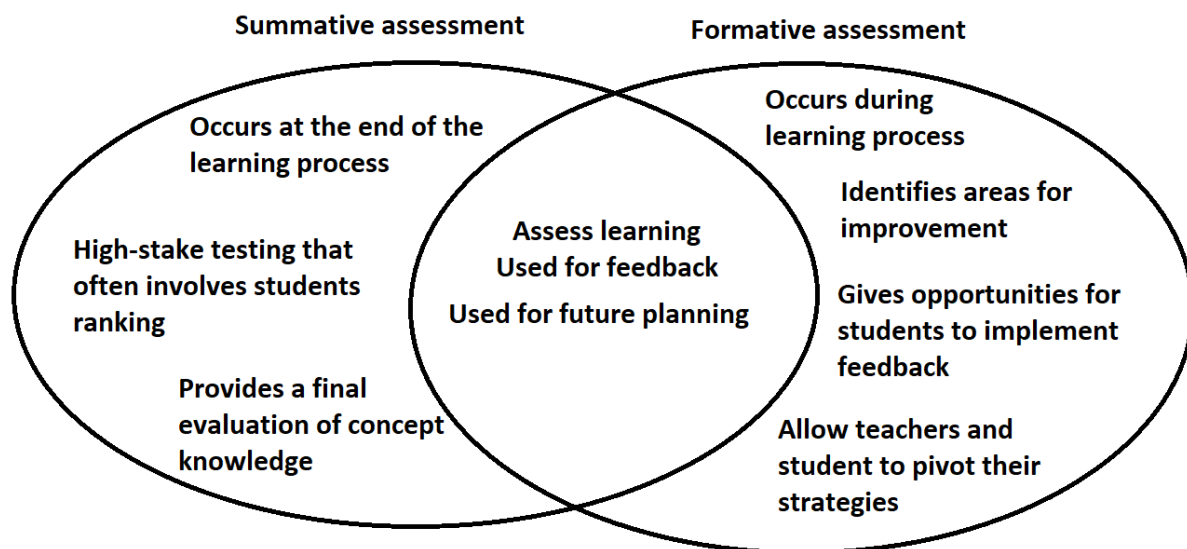


Figure 2. Differences between summative assessment and formative assessment.

2. Formative assessment in engineering education

Due to the preeminent significance of assessment processes in teaching, teachers must grasp some FA strategies for scientific education. FAe the process of gathering information on student thought in order to improve instruction and provide students with feedback eis a pillar of K–12 engineering education best practices. It permits teachers to comprehend how students comprehend, retain, and connect scientific concepts and theories [5, 6]. Consequently, the use of FA by teachers in the classroom is a crucial requirement and a subject of extensive study. Some research indicates that science teachers have had difficulty utilizing FA, despite FA being regarded as an essential professional skill for teachers. Examining FA teaching practices, the research reveals that FA is ineffective [10–12]. All of the aforementioned studies emphasized the significance of examining the classroom practices of science teachers regarding FA. In light of the benefits of implementing FA in the classroom, additional research is required to determine how FA is implemented in engineering classes. Professional development workshops can be a technique for motivating teachers to learn about FA given that effective implementation of FA practices is typically difficult for teachers [13, 14]. FA practices could

facilitate the collection and interpretation of data through activities that provide proof of evaluation. When utilizing FA to encourage students' development, engineering instructors require guidance with appropriate discourse frameworks. The findings suggested that not only should teachers' in-class methods be evaluated, but they should also be helped to improve these behaviors [15, 16]. Teachers who lacked a basic understanding of a pedagogical topic could not easily engage in FA interactions with their students and could not provide suitable feedback to aid in their development. FA would erase the barriers between curriculum, instruction, and assessment if teachers were supported and FA was utilized effectively in the classroom [12, 13]. According to this study's findings, the effective use of FA in science education and the advancement of teachers' progress in this area have been emphasized repeatedly. Even though they have received training on this topic, engineering teachers face a number of obstacles while implementing FA practices in the classroom. The purpose of this study is to explain, through a review of the literature, how FA practices are handled in science classrooms and how teachers implement these practices. This is an important and useful study for analyzing the studies on this topic holistically and directing future research. With the advent of qualitative research methodologies, the number of studies employing qualitative research methodologies has increased dramatically, and these studies have contributed to our understanding of phenomena and processes in context [12, 14–15]. Because the findings of such studies contain contextually bound conclusions that limit the ability to make meaningful generalizations across contexts, qualitative researchers have expressed a need for meta-synthesis methods that involve the careful synthesis of the findings of qualitative studies conducted in various contexts. In recent years, the demand for research employing meta-synthesis methodologies to inform evidence-based practice has increased. To enhance the qualitative research in this investigation, meta-synthesis studies are necessary. The absence of a meta-analysis of FA in science education is a major gap in the relevant research. Filling this void necessitates a thematic analysis of the relevant studies to discover common and distinct trends [18, 19].

3.1. The relationship between FA and students' attitudes

In the study, the attitudes of students toward social studies class were significantly more positive in the experimental group, which implemented FA practices, than in the control group, which did not. Similar research findings are documented in published works [20, 21]. Gezer et al. (2021) found that FA procedures in eighth-grade mathematics significantly improved [22] students' attitudes toward mathematics. The experimental group of students developed a positive attitude toward mathematics, according to this study. Nikou (2021) discovered that mobile learning assisted formative evaluation significantly increased the motivation and attitudes of fifth-year secondary school students toward learning in local culture class in a comparable experimental study [23]. According to Ozan and Kincal (2018), FA improved students' attitudes toward learning by emphasizing the importance of helping students understand their learning levels. In action research, formative feedback had a positive impact on students' evaluation attitudes and perspectives. In addition, the previous study discovered that students' desire to learn, self-assurance, and sense of responsibility increased. When analyzing the influence of FA methods on students' attitudes toward class in light of the findings of the present study and previous research, it is clear that FA procedures have a significant impact on students' attitudes. It can be inferred that FA practices, such as prioritizing learning and making up deficiencies rather than grading, teaching groups that require sharing

and cooperation rather than individual efforts, and assessing students according to their individual development levels rather than comparing them to one another, all contribute to the development of positive attitudes toward class among students [24].

3.2. The relationship between of FA and self-regulation skills

In the study, there was no significant difference between the self-regulation skills of students in the experimental group that utilized FA approaches and those in the control group that did not. Despite the lack of a statistically significant effect, it was discovered that FA methods improved students' self-regulation skills. Previous research examining the effect of FA on students' self-regulation skills found no significant differences between the experimental and control groups. The qualitative findings of the study reveal that during the learning process, students engaged in a number of cognitive techniques and self-regulatory learning behaviors. The students asserted responsibility for their own education and active participation in the learning process. FA, according to teachers, improved students' self-regulation skills by fostering a continuous and intentional engagement between instructor and student that was focused on learning effort and performance. FA enhances diagnostic exam performance by promoting the growth of self-regulation and metacognitive skills, as well as the advancement of students through educational standards [24, 25]. Previous research has examined the relationship between FA and self-regulation and emphasized that teachers who implement FA strategies must understand their students' self-regulatory learning processes in order to make accurate decisions. In order to cultivate students' self-regulation skills and boost their motivation, teachers frequently employ FA. The methods of "explaining, sharing, and comprehending the learning objectives and success criteria" and "students taking responsibility for their own learning" may make self-regulated learning a crucial component of an effective formative assessment (FA). Self-regulation skills encourage students to actively employ their cognitive abilities, exert effort to achieve their learning goals, seek assistance from their peers, teachers, or parents when necessary, and most importantly, assume responsibility for their own learning. Therefore, the type of formative assessment based on learners' learning and applications designed to eliminate learning deficits are directly related to students' self-regulation abilities [26, 27]. However, it could be argued that self-regulation skills can be developed gradually through the use of appropriate and consistent strategies. When the research and literature results were analyzed together, it was determined that FA techniques improved students' self-regulation skills but had no significant effect on them. This result can be explained by the fact that while FA procedures were implemented throughout the academic year, they were only implemented in the context of the social studies class, and self-regulation skills can change over time [25, 26].

4. Online-based FA

The incorporation of an online system into the FA procedure offers an outstanding opportunity to evaluate student success in a nontraditional manner. The first advantage is that students have a reasonable amount of time to complete tests, as long as they do so by the deadline. Second, students may retake the examination until they meet the predetermined standard. Finally, immediate feedback is provided so that students can address their weaknesses as soon as possible during the learning process. To achieve a successful FA process in an online environment, teachers must plan in advance and receive support from students and other

teachers who have access to adequate technology. Online formative evaluation can be implemented in a variety of ways and on a variety of platforms. Formative online evaluation can be implemented on a variety of platforms and in a variety of ways [28, 29]. There is no significant difference between traditional FA and online learning, and there are numerous examples of FA application in online learning, including the use of multiple choice questions, true or false questions, and matching questions to assess low-order thinking skills and short or lengthy essays to assess higher-order thinking skills [30, 31]. In addition, the use of particular platforms for online FA provides an additional distinction between traditional and online FA. Previous research has utilized multiple platforms as technical support for conducting online formative evaluation. These applications are used for formative assessment (online quizzes) utilizing multiple-choice test instruments [32–34].

5. Effective assessment procedure: validity, reliability and dishonesty

Validity in the context of online assessment requires ensuring a variety of pertinent assessment activities that promote contextual, inquiry-based learning, and multidimensional perspectives. Validity also refers to the effectiveness of formative feedback in terms of adequacy, immediacy, encouraging meaningful interactions, and supplying adequate learner support. In the context of online FA, dependability entails opportunities for ongoing documentation and monitoring of learning, which feed the feedback procedure. In addition, reliability refers to the availability of a variety of evidence of student learning from multiple sources. Providing ample opportunity to establish a shared interpretation of learning objectives and evaluation rubrics is an additional method for enhancing reliability. The issue of cheating in online FE, as it relates to students' true ownership of their work, depends on the degree of intrinsic validity and reliability. This suggests that dishonesty can be reduced by increasing the identified qualities of validity and reliability [35, 36]. This review also discovered that issues of validity and reliability, as well as dishonesty, take on additional dimensions in online contexts compared to face-to-face settings. One of these characteristics is the nature of interactivity in online versus face-to-face environments. Consequently, critical considerations must be taken into account during the design and implementation of FA in online environments in order to promote positive characteristics and mitigate associated risks. Due to barriers to physical interaction between students and teachers, it is crucial for effective communication that students receive clear, timely, ongoing, and sufficient feedback. In online contexts, feedback must be interactive so as to encourage further dialogue between the learner and the instructor or between learners. In other words, feedback should not be an end in itself; rather, it should generate additional opportunities for shared meaning, continuous learner support, and scaffolding [37, 38]. Moreover, it is crucial to maintain the immediacy of feedback in online contexts while allowing students sufficient time to respond. To support online learning and FA, asynchronous threaded discussions were utilized. Before responding or posing questions to other online participants, students must have sufficient time to collect their thoughts and evaluate their comprehension of the content or issues. Moreover, online education better accommodates individual learning styles and study plans. Integrating online FA while ensuring the aforementioned qualities will inevitably alter perceptions of validity and reliability and validate online FA as an innovative instructional strategy [38, 39].

6. Engagement with critical learning processes

Online FA can engage students in meaningful learning experiences by creating learning environments that encourage active learner participation. Engagement is necessary for meaningful learning. Engaged learning provides opportunities for learners to be active, creative, and critical, as well as creators of their own perspective and identity, thereby enhancing their learning experiences. Engagement is at the opposite end of a continuum from interaction, which involves the exchange of ideas and information between individuals. The learner advances along the continuum and becomes actively involved in the learning process [40, 41] when such exchanges continue and participants become naturally motivated to expand interactions accompanied by in-depth thoughts and critical analysis. Multiple researchers have shown that online formative assessment increases student engagement through meaningful interactions with content, peers, and/or oneself [42, 43]. They talk about how three kinds of interactions (learner-content or -activities, learner-others, and learner-self) can help with self- and peer-assessment in online learning environments. Through these interactions, online formative assessment not only increases student engagement but also facilitates a shared understanding of learning objectives and anticipated outcomes. Examining how different studies have highlighted these three types of interactions helps to clarify how they relate to FA in online contexts and how it increases learner engagement. There are meaningful interactions with information when online FA is situated within a genuine context that provides students with diverse, challenging, and engaging activities, resources, and/or technologies that are relevant to real-world circumstances. These contextual opportunities may include a variety of authentic learning and assessment tasks and projects that require students to use online tools that support collaborative inquiry, computer-based simulation tools, tools for finding and presenting knowledge, and/or rich databases for information and illustrative scenarios. Diverse authors have provided case studies of realistic situations that inspired and expanded the learner's autonomy and involvement, resulting in sustained engagement and meaningful learning experiences that enhanced the learner's ability to transfer information to other contexts. [40-42] These authors also investigated the role of online FA in enhancing student motivation and learning depth. Their findings demonstrate how scenario-based learning, as a method for supporting an authentic learning environment, can enhance in-depth, collaborative, self-regulated, and reflective learning. They demonstrated that realistic challenges can improve students' ability to transfer knowledge to real-world contexts and motivate them to become lifelong learners, as well as how students' engagement with a process-oriented curriculum affects academic achievement.

4. Conclusions

The evaluation method has evolved from evaluating students' comprehension by comparing their accomplishments to those of others to organizing instructional strategies to enhance classroom teaching or learning. This progression is also evident in literary evaluation concepts. In addition to the traditional concept of evaluating learning, which seeks to monitor the strengths and weaknesses of student learning, the concept of assessment for learning, which aims to promote student learning, has gained prominence. Consequently, FA as a form of assessment for learning plays a significant role in contemporary educational systems. FA is an evaluation strategy derived from the constructivist learning paradigm. The goal of constructivist learning theory is to promote effective and meaningful learning based on prior knowledge; as old ideas are transformed and adapted, new ideas emerge. Furthermore, learning

occurs through students' relationships with one another and their teachers, and students' active knowledge acquisition is of the utmost importance. The experimental group that incorporated FA practices had significantly more positive attitudes toward social studies class than the control group that did not. Similar research results have been documented in the published literature. There was no significant difference between the self-regulation skills of students who utilized FA approaches and those who did not. The incorporation of an online system into the FA method provides an exceptional opportunity to evaluate student performance in a nontraditional manner. Validity in the context of online assessment entails ensuring an assortment of relevant assessment activities that promote contextual, inquiry-based learning, and multidimensional perspectives. By fostering active learner participation through the creation of learning environments, online FA can engage students in meaningful learning experiences. Engagement is required for significant learning. Engaged learning provides learners with opportunities to be active, creative, and critical, as well as creators of their own perspectives and identities, thereby enriching their learning experiences.

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Competing Interest

No competing interest has been identified.

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