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Unlocking Potential: The Impact of Structured Digital Lessons and Self-Assessment Strategies on Mathematics Achievement and Motivation among School Students in the UAE

Farah Jawdat Khaled[a,*], Aysha Saeed Alghfeli[b]

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[a] **Corresponding Author:** Farah Jawdat Khaled, AlKhair School, Ministry of Education, United Arab Emirates.
E-mail: Farah.Khaled@ese.gov.ae
ORCID: https://orcid.org/0000-0002-9791-7696

[b] Aysha Saeed Alghfeli, AlKhair School, Ministry of Education, United Arab Emirates
E-mail: Aysha.Alghafli@ese.gov.ae
ORCID: https://orcid.org/0009-0002-5034-3573

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Abstract

This empirical study investigates the impact of structured digital lessons integrated with success criteria-based self-assessment strategies on sixth-grade students' achievement and motivation in mathematics. The study is situated within the context of the United Arab Emirates (UAE), aligning with the "We the UAE 2031" vision that emphasizes innovation, learner autonomy, and academic excellence. A quasi-experimental pre-test/post-test design was adopted, involving 120 students from AlKhair Public School in Al Ain. Two classes (n = 60) received instruction through structured digital lessons embedded with success criteria and self-assessment strategies, while the remaining two classes (n = 60) were taught using traditional instructional methods without targeted self-assessment components. All students completed mathematics achievement and motivation measures before and after the intervention. The findings indicate that students in the experimental group demonstrated notable improvements in both academic performance and motivational dimensions such as self-efficacy, intrinsic value, and task engagement, compared to their peers in the control group. The study concludes by highlighting the pedagogical significance of integrating success criteria-based self-assessment within digital instructional models and suggests practical implications for classroom practice and educational policy in the UAE. Directions for future research are discussed, including the expansion of this approach across different subjects and educational settings.

Keywords:

Structured Digital Lessons; Success Criteria; Self-Assessment; Mathematics Achievement; Student Motivation; We the UAE 2031 Vision; Self-Regulated Learning.

Introduction

The transformation of education in the digital age necessitates innovative and structured approaches that align with the evolving needs of students and educators (Aldhafeeri & Alotaibi, 2023). Academic progress, both at an individual and societal level, is intricately linked to the efficacy of the educational system (Sakız et al., 2021). As contemporary education shifts towards dynamic and interactive methodologies, the integration of structured digital lessons has emerged as a crucial component in fostering student engagement, self-regulation, and academic excellence (Moorhouse & Wong, 2022). Digital learning platforms, particularly Smart Learning Gateway LMS, have redefined traditional pedagogical approaches by incorporating structured lesson plans, real-time assessments, and interactive engagement tools that cater to diverse learning needs (Kong, 2021). These platforms align with the UAE's educational reform initiatives, particularly the "We the UAE 2031" vision, which aims to cultivate a knowledge-based economy driven by innovation and excellence (Matsumoto, 2019; Khaled & Alghfeli, 2024).

Self-assessment plays a pivotal role in this transformation, equipping students with the ability to critically analyze their progress and develop a proactive approach to learning (Yan, 2020). Panadero and Dochy (2014) defines self-assessment as an essential mechanism for measuring success criteria, particularly in mathematics education. The need for precise and adaptive assessment tools is more pronounced than ever, as educational systems strive to implement objective evaluation frameworks that support data-driven decision-making (Zeide, 2017). Through platforms like Smart Learning Gateway LMS, students gain access to tailored assessments, personalized feedback, and targeted learning pathways, ensuring that their academic journey is both structured and adaptable to their individual needs (Simić et al., 2016; Ikhsan et al., 2025). Research indicates that structured self-assessment strategies significantly enhance students' ability to monitor their own learning, a key predictor of academic success (Zimmerman & Schunk, 2013; Karaman, 2024).

The modern educational landscape underscores the importance of data-driven evaluation, necessitating a shift towards methodologies that enhance instructional quality and student outcomes (Rehan, 2023). The ability to monitor and adjust learning strategies in real-time enables students to develop metacognitive skills, fostering deeper engagement and academic resilience (Anthonysamy, 2021). Educational evaluation, when effectively integrated into digital platforms, serves as an indispensable tool in refining curriculum delivery and enhancing student motivation. As Almarode et al. (2020) argue, success criteria serve as a guiding framework that not only clarifies learning objectives but also enhances students' ability to navigate their academic journey with greater confidence and precision.

Moreover, motivation represents a crucial determinant of academic success, significantly influencing students' perseverance and overall performance (Howard et al., 2021). Recent studies highlight the interplay between digital learning environments, structured success criteria, and intrinsic motivation, demonstrating that students who engage in goal-oriented and self-directed learning exhibit enhanced academic performance (Scheel et al., 2022; Zhu et al., 2020). The implementation of Smart Learning Gateway LMS provides students with an immersive learning experience that reinforces self-efficacy, allowing them to track their progress, receive continuous feedback, and refine their learning strategies accordingly (Simić et al., 2016; Ikhsan et al., 2025). Research by Ryan et al. (2021) further supports this notion, emphasizing that motivation in education is driven by structured learning environments that encourage autonomy, competence, and relatedness.

The integration of success criteria into digital learning is instrumental in fostering self-regulated learning, a process that empowers students to take control of their academic development (Lai & Hwang, 2023). According to Zimmerman and Schunk (2013), self-regulated learning is a key predictor of student success, enabling learners to set goals, monitor their progress, and make necessary adjustments to their study habits. By embedding structured lessons within digital lessons, educators can provide a clear roadmap for students, ensuring that learning objectives are transparent and achievable. This structured approach, facilitated by platforms like Smart Learning Gateway LMS, not only enhances academic outcomes but also nurtures essential life skills such as problem-solving, critical thinking, and adaptability (Simić et al., 2016; Ikhsan et al., 2025).

Recent empirical studies further emphasize the effectiveness of self-regulated learning and interactive learning strategies in improving students' mathematical proficiency and motivation (Xu et al., 2023; Theobald, 2021; Ejubovic & Puška, 2019). Fostering independent and critical thinkers capable of addressing complex real-world challenges is a central pillar of the UAE's "We the UAE 2031" vision, which aims to empower learners with the skills and mindset needed for a rapidly evolving global landscape (Khaled & Alghfeli, 2024). The integration of digital learning tools, self-assessment, and success criteria aligns with this vision by preparing students with the analytical and cognitive skills required for the 21st-century knowledge economy (Khaled & Alghfeli, 2024). Moreover, the UAE's commitment to educational excellence is reflected in national assessments such as the Trends in International Mathematics and Science Study (TIMSS), which have demonstrated significant improvements in student achievement when innovative learning methodologies are employed (Wardat et al., 2022).

The need for research in this domain is evident, given the profound implications of structured digital learning on student achievement and motivation.

Understanding the interplay between digital learning environments, self-assessment, and success criteria is critical to optimizing pedagogical strategies and ensuring that students are well-equipped to navigate the complexities of modern education. This research aims to bridge the gap between traditional educational methodologies and contemporary digital learning solutions, offering insights into how structured digital lessons and self-assessment can be leveraged to enhance academic achievement and motivation. By aligning with modern educational initiatives and incorporating evidence-based practices, this study seeks to contribute to the ongoing evolution of education, ensuring that learning remains meaningful, engaging, and impactful in the digital era.

Problem Statement

Aligned with the "We the UAE 2031" vision for education, which prioritizes the development of students' skills and competencies through cutting-edge research and advanced educational methodologies, the United Arab Emirates continues to experience transformative advancements that are redefining the educational experience (Khaled & Alghfeli, 2024). The UAE has made remarkable progress in implementing ambitious reforms to align with its national vision, fostering an environment of innovation and excellence (Karabchuk et al., 2022).

As the educational sector undergoes rapid digital transformation, structured digital lessons and self-assessment strategies have emerged as crucial tools in fostering student autonomy, self-regulation, and academic excellence (Al Zarooni, 2023; Al Murshidi, 2019). Research in this domain, particularly regarding their integration in mathematics education, is essential for ensuring that UAE schools leverage digital advancements to enhance learning outcomes and student motivation (AlKhaza'leh et al., 2023).

Given that mathematics is regarded as the language of modern sciences and a fundamental pillar of a knowledge-based economy, the UAE has placed significant emphasis on enhancing mathematical proficiency. This is evident in the introduction of specialized curricula in analytical and innovative thinking. Furthermore, increased student participation in applied mathematical activities outside the classroom reflects the country's commitment to achieving its educational vision (Al Zarooni, 2023; Badawy, 2022; ElSayary, 2021).

Despite notable progress in mathematics education, national and international assessments continue to highlight challenges that need to be addressed. The TIMSS has reported a significant improvement in the performance of UAE students in mathematics and science between 2015 and 2023 (Wardat et al., 2022). However, there remains an urgent need to adopt contemporary learning strategies that incorporate self-regulated learning and interactive methodologies. These approaches can better equip students with the skills to tackle academic challenges with confidence and flexibility (Lai & Hwang, 2023).

In this regard, Her Excellency Sarah bint Yousif Al Amiri emphasized that these improvements are a direct result of investments in human capital and the creation of an enabling educational environment. Such an environment prepares students to become future leaders in thought and innovation (Robinson & Aldridge, 2022). Nonetheless, existing studies indicate that while structured digital lessons and self-assessment techniques have demonstrated effectiveness in fostering engagement and improving student outcomes globally, their integration within the UAE's educational system remains underexplored (Ejubovic & Puška, 2019).

Furthermore, research examining the relationship between self-assessment, success criteria, and structured digital learning in mathematics remains limited (Haddad et al., 2024). This presents an opportunity to investigate how these elements can optimize learning outcomes both nationally and globally. The urgency of this research is further underscored by findings from an exploratory pilot study conducted by the researchers, which revealed persistent challenges among middle school students in mathematics education.

The pilot study conducted by the researchers highlighted continued reliance on traditional teaching methods, limited application of self-directed learning strategies, and a general lack of engagement with interactive educational tools. Additionally, interviews with mathematics teachers and coordinators indicated widespread deficiencies in students' problem-solving skills, motivation levels, and perseverance when faced with cognitively demanding tasks.

A recurring theme in these interviews was the absence of structured self-assessment strategies and success criteria. These tools could provide students with a clearer understanding of their learning progress and encourage greater academic ownership. As the UAE continues to advance its educational system, research on structured digital learning and self-assessment is vital in cultivating an environment that nurtures skill development, encourages independent learning, and aligns with the "We the UAE 2031" vision (Khaled & Alghfeli, 2024; Haddad et al., 2024).

By enhancing research efforts in structured digital education, the UAE can ensure its educational system remains at the forefront of modern advancements. This would equip students with the necessary tools for future success (Al Zarooni, 2023; Badawy, 2022;

ElSayary, 2021). The integration of success criteria into structured digital lessons is instrumental in achieving the UAE's long-term educational goals, particularly under the "Excellent Education in U.A.E. 2071" vision.

Success criteria provide clear benchmarks for students, fostering self-directed learning and improving problem-solving and analytical skills. When integrated with formative assessment and digital tools, they support goal setting, progress tracking, and reflection (Moorhouse & Wong, 2022). Coupled with a growth mindset, this approach empowers students to embrace challenges and develop core skills like critical thinking and independence (Stohlmann & Yang, 2024).

These principles align with the UAE's broader educational framework, which prioritizes transparency, participatory learning, and globally competitive education (Matsumoto, 2019). By embedding structured success criteria within digital learning platforms, UAE schools can empower students with autonomy and resilience, promoting deeper engagement and higher academic achievement.

While success-based self-assessment strategies have been extensively studied in global contexts (Karaman, 2024; Yan, 2020; Vrieling et al., 2018), their direct impact on student achievement and motivation within the UAE's educational system remains insufficiently examined. This study aims to bridge this gap by investigating the role of structured digital lessons and success criteria as a self-assessment strategy in enhancing the academic achievement and motivation of sixth-grade mathematics students in UAE schools.

The findings will contribute to a deeper understanding of the relationship between success criteria and self-assessment practices, providing evidence-based insights into their impact on student achievement. Moreover, this research seeks to inform educational policies and instructional methodologies, ensuring alignment with the objectives of the "We the UAE 2031" vision. By addressing the gap in structured digital learning methodologies and self-assessment frameworks, this study will support UAE schools in fostering an innovative, adaptive, and student-centered educational system, ensuring sustained excellence and empowerment in mathematics education.

Objectives of the study

This study seeks to explore the role of structured digital lessons and self-assessment through success criteria in enhancing mathematics achievement and motivation among students at Al-Khair School, UAE. By integrating these pedagogical approaches, this research aims to provide empirical insights into their effectiveness in fostering student autonomy, improving academic performance, and sustaining long-term learning engagement. The study is guided by the following objectives:

1. To assess how structured digital lessons incorporating self-assessment through success criteria influence students' mathematics achievement in comparison to traditional learning approaches.

2. To examine the effect of structured digital lessons integrated with self-assessment through success criteria on students' motivation compared to traditional learning approaches.

Research Questions and Hypotheses

Research Questions

1. How do structured digital lessons incorporating self-assessment through success criteria impact students' mathematics achievement compared to traditional learning approaches?

2. How do structured digital lessons incorporating self-assessment through success criteria influence students' motivation compared to traditional learning approaches?

Hypotheses

H1: Students exposed to structured digital lessons integrated with self-assessment through success criteria will demonstrate significantly higher mathematics achievement compared to those receiving traditional instruction, as measured by pre-test and post-test scores.

H2: Students participating in structured digital lessons integrated with self-assessment through success criteria will exhibit significantly higher motivation levels compared to those in traditional learning environments, as measured by student motivation surveys and engagement metrics.

Literature Review

The modern educational systems places increasing emphasis on integrating technology-driven practices to elevate students' academic outcomes and personal growth, especially in subjects like mathematics where conceptual understanding and procedural fluency are crucial (Cullen et al., 2020). Several studies have demonstrated the positive impact of digital tools and platforms on learners' engagement and performance. For instance, Chao et al. (2016) found that interactive lesson modules significantly enhanced students' motivation and conceptual clarity, while Kaplar et al. (2022) reported that students using structured digital lessons in mathematics displayed better problem-solving skills and higher self-regulation levels compared to those in traditional settings. Similarly, Candel et al. (2020) highlighted the importance of immediate feedback within digital environments, indicating that timely corrections and guided instructional content helped learners overcome conceptual barriers more effectively.

Beyond academic achievement, a growing body of research underscores the role of technology-enhanced education in supporting metacognitive development, including self-reflection, goal setting, and self-monitoring (Yorganci, 2025; Duangnamol et al., 2018). Engeness (2021) demonstrated how structured digital lessons, when combined with opportunities for self-assessment, can promote deeper engagement and foster a sense of ownership over the learning process. This aligns with the findings of Schmid et al. (2021), who noted that technology-rich classrooms cultivate an environment where students actively track their progress and willingly adapt their strategies to meet specific learning targets. In mathematics education, these self-directed behaviors are especially significant, as learners often benefit from iterative cycles of practice, feedback, and reflection to reinforce understanding (Yıldızlı & Saban, 2016).

Within this evolving educational context, structured digital lessons have emerged as a foundational framework for implementing pedagogical practices that emphasize learner autonomy and sustained motivation (Scheel et al., 2022). In tandem with self-assessment and well-defined success criteria, such lessons enable students to pinpoint their strengths and areas for improvement, thereby channeling their efforts strategically. Several studies corroborate that explicitly stated success criteria and consistent self-evaluation enhance students' confidence and willingness to tackle challenging tasks (Lopez Carrillo et al., 2024; Aldosari & Alsager, 2023). This synergy between clarity of learning goals, technology-driven instruction, and reflective practice has been associated with notable gains in mathematics achievement, higher-order thinking skills, and positive attitudes toward learning (Cullen et al., 2020; Christopoulos et al., 2020).

In the United Arab Emirates, there is a pronounced emphasis on leveraging educational technology to realize the nation's broader vision of innovation and excellence, as articulated in "We the UAE 2031" vision (Efstratopoulou et al., 2024; Sakr & Abdalla, 2024). Across UAE schools, teachers and administrators have recognized that structured digital lessons, combined with self-assessment practices and clear success criteria, can address diverse learning needs and mitigate gaps in mathematics achievement (Khaled & Alghfeli, 2024). Through the systematic integration of these components in everyday instruction, students benefit from a well-defined roadmap for progress, ongoing feedback loops to guide development, and the motivation to persevere through challenging mathematical problems (Zhang et al., 2022; Hansen, 2021; Barana et al., 2018). AlKhair School exemplifies these strategies in action, demonstrating how embedding technology-driven approaches within the curriculum can yield tangible improvements in student outcomes.

Against this backdrop, the present theoretical framework starts by examining the role of structured digital lessons in shaping the learning experience, followed by an in-depth exploration of self-assessment as a cornerstone of learner autonomy, and finally a discussion on success criteria as a guiding pillar for both teaching and learning. The review concludes by illustrating how these interwoven elements synergistically enhance mathematics performance and foster sustained motivation within the UAE educational context.

Structured Digital Lessons

Structured digital lessons are carefully designed online or technology-augmented instructional modules that provide clear objectives, interactive learning activities, and immediate feedback to learners (Ikhsan et al., 2025). These lessons typically incorporate diverse digital resources—such as multimedia presentations, virtual simulations, interactive quizzes, and discussion forums—to address various learning styles and maintain student engagement (Singhal et al., 2021). Importantly, they often allow learners to proceed at their own pace, revisiting content as needed for deeper understanding (Sorgenfrei & Smolnik, 2016).

Research has consistently highlighted the advantages of integrating structured digital lessons into mathematics curricula. Students benefit from the immediate feedback loops these lessons offer, which foster metacognitive awareness and help correct misconceptions early in the learning process (Candel et al., 2020). For instance, interactive problem-solving platforms enable real-time tracking of student inputs and error patterns, allowing for timely instructional adjustments by both the learner and the teacher (Ikhsan et al., 2025). This immediacy of feedback can be especially powerful in mathematics, where conceptual misunderstandings, if left unaddressed, can impede mastery of advanced topics (Candel et al., 2020).

Furthermore, structured digital lessons can be adapted to accommodate various levels of difficulty, scaffolding the learner's journey from foundational skills to more complex tasks (Kang, 2018). By providing differentiated pathways based on performance data, these lessons support students who may need extra practice while simultaneously challenging those ready to move ahead (Rao et al., 2021). This adaptability is tied to heightened motivation; learners feel a sense of agency when they observe personalized progress trajectories, spurring them to persist in mastering difficult mathematical concepts (Chao et al., 2016).

Another critical feature of structured digital lessons is the capacity to integrate communication tools such as online discussion boards, collaborative problem-solving rooms, and peer-review systems (Moorhouse & Wong, 2022). These elements foster a communal learning atmosphere where students exchange ideas, challenge one another's thinking, and develop collective problem-solving strategies (Simić et al., 2016; Ikhsan et al., 2025). Alajarmeh and Rashed (2019) indicates that peer collaboration within digital environments can enrich understanding by exposing learners to diverse perspectives and solution methods. In short, structured digital lessons lay the groundwork for an engaging, student-centered milieu—one that aligns effectively with contemporary pedagogical goals of fostering independent, reflective, and motivated learners (Engeness, 2021).

Self-Assessment Strategy through Success Criteria

Self-assessment is a reflective practice in which learners critically evaluate their own work in light of established criteria (Almasraf, 2023). It involves judging the quality, completeness, and accuracy of their performance, thereby identifying strengths and areas needing improvement (Garshasbi et al., 2019). While self-assessment can be conducted in traditional classroom settings, its integration with structured digital lessons enhances both the immediacy and accuracy of the feedback loop (Zare et al., 2022). Digital platforms frequently embed mini-quizzes, polls, or interactive checkpoints that prompt students to gauge their understanding, compare their answers with model solutions, and adjust their study strategies as needed (Cullen et al., 2020).

One of the core benefits of self-assessment is the development of learner autonomy and responsibility (Sakr & Abdalla, 2024). As students actively monitor their progress, they become more aware of the cognitive strategies that contribute to effective learning. This metacognitive awareness fosters strategic thinking and planning: learners can set short-term goals, develop personalized study plans, and track their progress toward mastery (López Carrillo et al., 2024). Empirical studies suggest that students who engage in regular self-assessment exhibit better academic performance and a stronger sense of ownership over their learning processes (Almasraf, 2023; Khaled & Alghfeli, 2024).

Moreover, self-assessment plays a pivotal role in bolstering motivation (Howard et al., 2021). When learners can visually chart their progress or see improvements in real time—such as a rising score in an online practice environment—they experience heightened confidence and a willingness to tackle more challenging tasks (Van Wart et al., 2019). This cyclical pattern of challenge, feedback, and re-engagement cultivates resilience and adaptive learning behaviors, key elements of a growth mindset (Schunk, 2023). It is within this reflective process that success criteria serve as essential referents, guiding learners in their self-evaluation and helping them understand precisely how to move from current performance to targeted outcomes (Eagan, 2023).

Success criteria are explicit statements that define the quality of expected performance in a given task, often detailing the learning goals, the depth of understanding required, and the type of evidence that demonstrates mastery (Almarode et al., 2020). They are not merely checklists; rather, they represent a transparent framework that teachers and learners use to gauge growth (Garshasbi et al., 2019). By clarifying what successful work looks like, success criteria help students set realistic performance benchmarks and navigate the steps needed to improve (Eagan, 2023).

In mathematics education, success criteria may include mastery of procedural knowledge (e.g., accurate algebraic manipulation), conceptual understanding (e.g., explaining the rationale behind a given theorem), and application skills (e.g., solving real-world problems using learned concepts) (Khaled & Alghfeli, 2024). Research has shown that students' motivation increases when they understand the specific targets they must meet (Panadero et al., 2017). Clear success criteria allow them to measure progress concretely and to seek targeted assistance from teachers or peers whenever they detect a gap in knowledge or skills (López Carrillo et al., 2024).

The utility of success criteria is maximized when coupled with timely feedback. For instance, constructive feedback that highlights how closely a student's work aligns with the stated criteria bolsters self-efficacy and directs learners toward strategies for improvement (Khaled & Alghfeli, 2024). This synergy between clear goals, self-evaluation, and meaningful feedback is integral to nurturing self-regulated learners, as students internalize the benchmarks and continuously refine their work until it meets or exceeds those benchmarks (Cullen et al., 2020; Christopoulos et al., 2020).

Relationship between Structured Digital Lessons and Self-Assessment Through Success Criteria to Enhance Math Achievement

One of the core propositions in contemporary educational research is that structured digital lessons and self-assessment through success criteria are mutually reinforcing elements that promote math achievement. When students engage with well-designed digital content, they receive immediate, targeted feedback tied to predefined learning goals—feedback that can, in turn, guide their self-assessment processes (Christopoulos et al., 2020). This cyclical relationship plays a crucial role in mathematics instruction, given the cumulative nature of math concepts and the rapid identification of errors that immediate digital environments can offer (Zhang et al., 2022; Hansen, 2021; Barana et al., 2018). Students who routinely evaluate their progress against clear benchmarks not only detect gaps in their understanding promptly but also develop a stronger sense of ownership over their own learning (Eagan, 2023). As a result, self-assessment—a pivotal metacognitive skill—becomes more effective when learners have structured digital resources that reinforce transparency and goal-orientation.

A growing body of research indicates that structured digital lessons have a positive impact on students' mathematics achievement, largely due to their interactive components and potential for immediate feedback. In a frequently cited meta-analysis, Ran et al. (2021) found that the use of computer-based instructional tools significantly improved K–12 students' mathematics learning outcomes, highlighting the importance of technology integration for conceptual understanding.

Similarly, Zhang et al. (2015) examined a range of educational technology applications in mathematics and concluded that well-designed digital lessons can yield moderate to strong effects on students' test scores. They emphasized that ongoing feedback and interactivity are pivotal in sustaining student engagement and reinforcing newly acquired skills. A review by Higgins et al. (2019) further supported these findings, arguing that the successful use of digital technology in mathematics relies on both teacher preparedness and the strategic use of interactive software that keeps learners motivated. More recent work by Yeh et al. (2019) demonstrated how digital game-based learning in primary math classrooms contributed not only to higher achievement but also to increased enjoyment and lower math anxiety.

Alongside the rise of digital instructional tools, extensive research has underscored the effectiveness of self-assessment through success criteria in boosting mathematics performance. Panadero et al. (2017) noted that when learners are given explicit benchmarks to measure their own work, they develop stronger metacognitive skills—such as planning, monitoring, and regulating their learning strategies. Further evidence from Raaijmakers et al. (2019) suggests that learners who regularly compare their output to clear success criteria demonstrate increased accuracy in judging their mastery level, prompting timely adjustments in study habits and resulting in better test performance.

Relationship between Structured Digital Lessons and Self-Assessment Through Success Criteria to Enhance Motivation

A growing body of literature underscores the positive impact of structured digital lessons on learners' drive to succeed. In a systematic review, Schindler et al. (2017) reported that technology-rich environments encourage higher engagement levels by catering to diverse learning styles and providing individualized feedback. Similarly, Dinh and Phuong (2024) examined massive open online courses (MOOCs) and found that well-organized digital instruction can reduce demotivation by offering students flexible pacing and immediate evaluative information.

Alongside the integration of technology, extensive research has highlighted the role of self-assessment through success criteria in boosting motivation. Moorhouse and Wong (2022) explained that clear benchmarks and reflective prompts not only help students gauge their current standing but also cultivate self-efficacy, leading them to approach challenging tasks with more confidence. Li et al. (2021) echoed this perspective, showing that explicit success criteria in both science and math contexts led to greater persistence and curiosity among learners.

Reinforcing these insights, Puente-Díaz (2012) posited that when learners understand and internalize success criteria, they are more likely to set meaningful personal goals and embrace a growth mindset. In the same vein, Yan (2020) demonstrated that digital self-assessment tools—designed around well-defined criteria—help university students remain motivated over longer periods, as they can regularly see the direct impact of their efforts.

Collectively, these studies illustrate that weaving self-assessment through success criteria into structured digital lessons can significantly bolster learners' motivation. By offering precise indicators of progress and real-time feedback, digital platforms cater to students' need for autonomy, competence, and relatedness—fundamental ingredients for nurturing long-term motivation (Chiu, 2022).

While global research on structured digital lessons and self-assessment is expanding, studies in the UAE remain limited. Though some highlight the benefits of technology and reflective learning (Efstratopoulou et al., 2024), few examine their impact on motivation and math achievement in middle grades. Given the UAE's unique context, this study investigates how structured digital lessons and self-assessment using success criteria affect sixth-grade students' motivation and achievement, offering insights for local educational practice.

Methodology

The current study adopted a quasi-experimental pretest-posttest design to assess the impact of structured digital lessons and self-assessment using success criteria on students' mathematics achievement and motivation. Conducted at AlKhair School, UAE, this research integrates digital learning strategies with self-regulated assessment techniques to optimize student performance, aligning with the UAE's 2031 educational vision. The study examines how structured digital lessons embedded with self-assessment strategies empower students to take ownership of their learning process, enhancing both their mathematical proficiency and intrinsic motivation.

Given administrative constraints preventing full random selection, intact classes were assigned as study samples rather than randomly assigning students. The study was conducted during Term 1 of the 2023/2024 academic year, involving four sixth-grade classes. The selection of the experimental and control groups was determined through random assignment. The experimental group engaged in self-regulated assessment methods, incorporating detailed success criteria within structured digital lessons. In contrast, the control group followed traditional assessment methods without explicit structured digital lessons and success criteria.

To establish a baseline for student learning, a researcher-designed diagnostic pre-test, aligned with the national curriculum, was administered to both groups. The intervention's effectiveness was evaluated using post-test scores from the UAE Ministry of Education's national mathematics assessments. The Final Ministry Mathematics Exam served as the post-test for achievement, measuring concept mastery and procedural fluency. Additionally, students' Mathematical Motivation Questionnaire (MMQ) scores were analyzed to assess intrinsic and extrinsic motivation in relation to mathematics learning.

Beyond academic performance, the study highlights the role of interactive and self-reflective tasks in enhancing mathematical proficiency. It also explores how goal setting, feedback loops, and adaptive assessments contribute to increasing students' intrinsic motivation, fostering deeper engagement with the learning process, and promoting sustained academic growth

Participants

This study was conducted at AlKhair Public School in Al Ain, United Arab Emirates, during the academic year 2023/2024. The sample consisted of 120 sixth-grade female students from the general stream, all following the standardized curriculum prescribed by the UAE Ministry of Education. This ensured consistency in academic background and minimized the influence of external variables on study outcomes. Additionally, all students shared a common socio-cultural environment, further enhancing the homogeneity of the sample. The students were divided into two groups: an experimental group of 60 students, who were exposed to structured digital lessons incorporating self-assessment through success criteria to enhance mathematics achievement and motivation, and a control group of 60 students, who continued with traditional teacher-led instruction.

AlKhair Public School was selected for this study due to the researchers' professional affiliation with the institution and its pioneering implementation of innovative teaching and learning strategies among public schools in Al Ain. The school's administration actively supports cutting-edge educational strategies aimed at optimizing student performance, aligning with the UAE's 2031 educational vision. This proactive approach makes it an ideal setting for evaluating the effectiveness of new instructional methods.

To verify the initial equivalence between the experimental and control groups in terms of academic achievement, a diagnostic pre-test was administered prior to the implementation of the instructional intervention. This assessment aimed to ensure that both groups demonstrated similar levels of academic readiness at the outset of the study. An independent sample t-test was conducted to examine whether any statistically significant differences existed in the pre-test scores between the two groups. The results, presented in Table 1, confirm the absence of significant differences, thereby validating the comparability of the groups before the intervention.

Table 1
Independent sample t-test results for pre-achievement test scores by group

Group	*N*	Mean	*sd*	t-value	*df*	p-value
Control	60	40.92	14.22	0.576	118	0.566
Experimental	60	39.33	15.85			

Table 1 shows that the value of t is not statistically significant ($p > 0.05$), indicating no statistically significant differences between the mean scores of the experimental and control groups in prior achievement levels. This confirmation of equivalence ensures that any subsequent effects on academic achievement can be reliably attributed to the teaching strategies and intervention methods used in the study.

Moreover, to establish baseline equivalence in mathematical motivation between the experimental and control groups, the MMQ was administered as a pre-test. This instrument evaluates five core dimensions: intrinsic value, utility value, self-efficacy, self-regulation, and test anxiety (reverse-scored). Independent sample t-tests were conducted for each dimension to determine if any statistically significant differences existed prior to the instructional intervention. The results, detailed in Table 2, indicate no significant differences across any of the motivation dimensions, supporting the conclusion that the two groups were motivationally equivalent at the beginning of the study.

As shown in Table 2, none of the t-values were statistically significant ($p > 0.05$), indicating no significant differences between the experimental and control groups in any of the MMQ dimensions or in total motivation scores at the pre-test stage. This confirms that the groups were equivalent in terms of mathematical motivation prior to the intervention, ensuring that any post-test differences can be attributed to the instructional methods rather than pre-existing disparities.

Study Instruments and Procedure

Procedure

The instructional program implemented in Al-Khair School for sixth-grade mathematics, as part of the study integrates structured digital lessons with success criteria-based self-assessment. This model supports the development of academic achievement and motivation by combining the clarity and consistency of digital lesson design with the reflective practices encouraged by self-assessment. The program aligns with the "We the UAE 2031" vision by promoting innovation and educational excellence through technology-enhanced learning environments and formative assessment practices that empower students to understand learning objectives and evaluate their own progress.

The program was implemented over a period of 12 weeks during the first academic term, totaling 72 instructional sessions—6 sessions per week, with each session lasting 60 minutes. It was built around the official Grade 6 mathematics curriculum, covering four main units: ratios and rates, decimals and percentages, operations with multi-digit numbers, and integers, rational numbers, and the coordinate plane. While fully adhering to the national curriculum, the lessons were digitally structured to present clear learning goals and embedded success criteria at each stage. Self-assessment was systematically incorporated through color-coded indicators and reflection tools, allowing students to track their understanding in real time. This integration of structured digital instruction with continuous self-assessment aimed to foster clarity, confidence, and measurable improvement in both mathematical performance and student motivation.

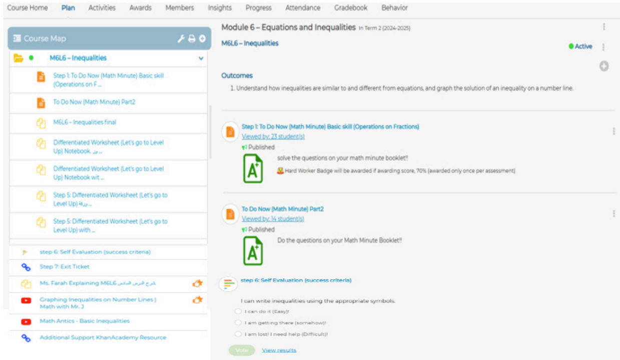
At the core of this program lies the step-structured lesson design, a strategy that segments each lesson into defined, sequential learning stages. Each stage presents a clear objective aligned with success criteria displayed on the digital board and LMS interface (as seen in Figure 1). Lessons begin with a "To Do Now" prompt, followed by explicit learning targets and a visual progress tracker using the lesson step strip, which promotes planning, time management, and goal setting—key components of self-regulated learning.

Table 2

Independent sample t-test results for MMQ pre-test scores by group

MMQ Dimension	Group	*N*	Mean	*sd*	t-value	*df*	p-value
Intrinsic Value	Control	60	2.95	0.64	0.412	118	0.681
	Experimental	60	3.02	0.61			
Utility Value	Control	60	3.15	0.58	0.395	118	0.694
	Experimental	60	3.20	0.60			
Self-Efficacy	Control	60	2.91	0.67	0.578	118	0.565
	Experimental	60	2.85	0.65			
Self-Regulation	Control	60	2.83	0.62	0.447	118	0.656
	Experimental	60	2.77	0.60			
Test Anxiety	Control	60	4.12	0.73	0.529	118	0.598
	Experimental	60	4.20	0.75			
Total Motivation	Control	60	3.19	0.47	0.361	118	0.719
	Experimental	60	3.24	0.49			

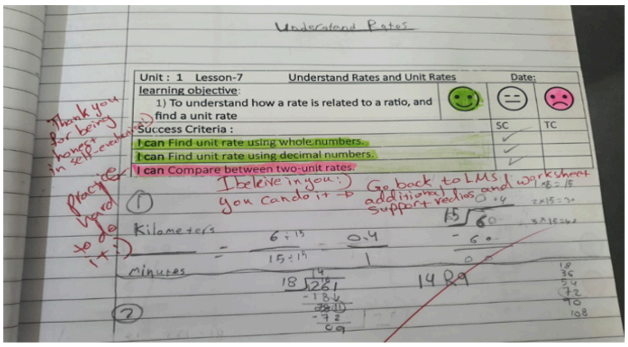
Figure 1
Step-Structured Lesson Design on LMS



Students engage in daily short assessments known as "Math Minutes" during the opening of each class. These quick tests serve both as review and diagnostic tools, providing immediate feedback. Students chart their scores on personal graphs, fostering accountability and tracking growth over time. This process enhances metacognitive awareness, as students identify gaps and take ownership of their progress.

The self-assessment strategy is implemented after each lesson objective is taught and practiced. Using color-coded success criteria stickers (see Figure 2), students reflect on their mastery: red for "need improvement," yellow for "partial understanding," and green for "mastery." This visual, formative tool helps students monitor their learning in real time, while enabling the teacher to deliver targeted feedback.

Figure 2
Color-coded success criteria stickers used for student self-assessment and real-time feedback



Following the self-assessment strategy that was recommended by Khaled and Alghfeli (2024), students receive differentiated tasks tailored to their performance levels. Those who indicate red engage in remedial activities labeled "Let's Go" and "Continue," designed to reinforce foundational concepts. Students at the yellow level proceed to supportive activities such as "One Step to Go" and "Two Steps to Go," which help bridge learning gaps and prepare them for more advanced content. Meanwhile, green-level students explore enrichment activities labeled "Level Up" and "A+," which promote higher-order thinking skills in alignment with Bloom's Taxonomy (see Table 3). This differentiation ensures every student receives an appropriate level of challenge, directly supporting self-paced learning and maintaining high engagement.

Table 3
The designed level stickers and success criteria corresponding to Bloom's Taxonomy model (Khaled & Alghfeli, 2024)

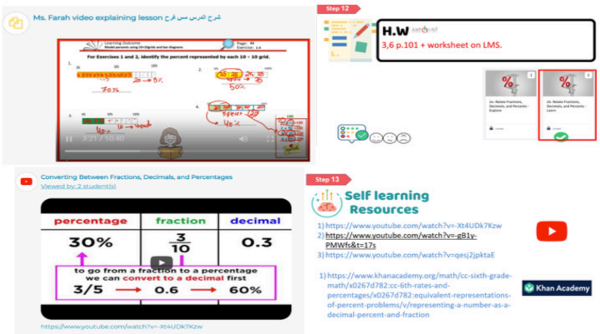
Stickers' levels for activities	Bloom's Taxonomy Levels	Success criteria
 	Remember: Recall basic math facts, terms, and concepts. Activities: listing formulas, identifying shapes, and retrieving definitions. Understand: Grasp the meaning of math concepts by interpreting and explaining them. Activities: summarizing procedures, explaining ideas, and comparing methods.	Mastery of 1 or none of success criteria.
 	Apply: Use learned math concepts in new situations. Activities: solving problems, applying formulas, and demonstrating procedures. Analyze: Break down math problems to understand their structure. Activities: comparing methods, identifying patterns, and organizing data.	Mastery of 2 of success criteria.
 	Evaluate: Make judgments about math solutions based on criteria. Activities: critiquing methods, assessing solutions, and justifying answers. Create: Generate new ideas and solutions in math. Activities: designing experiments, constructing models, and producing new problem-solving methods.	Mastery of 3 of success criteria or more.

The program also incorporates visual aids and motivational tools, including interactive success-tracking posters and level-based achievement badges, reinforcing a growth mindset. Throughout each session, students are encouraged to reflect, revise, and revisit their goals, which nurtures a cycle of self-regulation involving planning, monitoring, and evaluating.

Digital integration plays a vital role in amplifying the program's success. Lessons are hosted on an LMS platform, where interactive slides, embedded quizzes, polls, and discussion boards enable students to engage actively and independently. Teachers use the platform to embed additional resources like video tutorials, interactive worksheets, and Khan Academy links for extended practice, as referenced in Figure 3.

Figure 3

LMS platform interface featuring interactive lessons, quizzes, and supplementary digital resources



Finally, regular feedback sessions and peer discussion forums provide a safe space for reflection and collaborative learning. Teachers act as facilitators, shifting the responsibility of learning to the students, thereby reducing teacher talk to 20% and increasing student-led engagement to 80%.

This innovative framework supports a comprehensive self-regulated learning model, where structured digital instruction, continuous formative feedback, self-assessment, and differentiation converge to build academic confidence and independence. The program sets a clear path toward meeting the goals of "We the UAE 2031" vision by developing learners who are reflective, resilient, and ready to lead in a rapidly evolving world.

Study Instruments

To ensure the equivalence of the experimental and control groups before implementing the instructional intervention, a pre-test assessment was administered to measure academic achievement through a diagnostic test and evaluate students' motivation using the MMQ. An independent sample t-test was conducted to determine whether any statistically significant differences existed between the groups in their pre-test results. The analysis revealed no statistically significant differences between the two groups ($p > 0.05$), confirming their equivalence in academic readiness and motivation as presented in Table 1 and Table 2 previously.

The diagnostic test tool was utilized as a pre-test assessment, designed by the teacher in a format similar to the final ministerial exam. To ensure its validity, the test was reviewed by a panel of five experts in mathematics education, assessment, and psychometrics. The experts provided structured feedback on the clarity, alignment with curriculum objectives, and appropriateness of difficulty levels. Based on their recommendations, minor modifications were made to refine wording, eliminate ambiguous items, and improve content alignment with expected student competencies

Furthermore, an item analysis was conducted to evaluate the difficulty index and discrimination power of each question. The difficulty index ranged from 0.35 to 0.78, ensuring a balanced distribution of item complexity. The discrimination index, which measures an item's ability to differentiate between high- and low-performing students, ranged from 0.42 to 0.91, indicating strong validity.

The reliability of the diagnostic test was assessed using Cronbach's alpha coefficient, which reached 0.85, demonstrating a high level of internal consistency. The correlation coefficients of test items ranged from 0.65 to 0.91, further confirming the instrument's reliability. This test was employed to verify the equivalence of the two groups in prior mathematical achievement, ensuring that the final results accurately reflect the impacts of the implemented educational strategies.

The primary measure of achievement in this study was the Final Mathematics Exam, prepared by the UAE Ministry of Education. This post-test assessment is designed in accordance with national standards that encompass various cognitive domains, including recall, application, analysis, and evaluation. The exam consists of 15 multiple-choice questions administered electronically and 5 free-response questions presented in a paper-based format. These free-response questions aim to assess students' ability to apply mathematical concepts in structured problem-solving scenarios. Recognized as an official assessment tool by the Ministry, this exam ensures the integration of comprehensive evaluation criteria under the guidance of educational experts. Given that it is a standardized national measure implemented across UAE schools, its validity and reliability have already been established, eliminating the need for further psychometric testing in this study.

The study also employs the Mathematics Motivation Questionnaire (MMQ) designed and validated by Fiorella et al. (2021) to assess students' motivation towards learning mathematics. The MMQ was adapted from the Science Motivation Questionnaire (SMQ) originally developed by Glynn et al. (2011) to measure motivation in science education. The SMQ was based on well-established theories of academic motivation, including expectancy-value theory and self-determination theory. However, early applications of the SMQ revealed limitations in its internal structure, as some factors combined multiple constructs that were traditionally treated as distinct, such as self-efficacy and assessment anxiety (Fiorella et al., 2021).

To refine the instrument for mathematics education, Fiorella et al. (2021) modified the SMQ by replacing references to "science" with "math" and re-examining the theoretical alignment of the items. The resulting MMQ measures six distinct factors of mathematical motivation: intrinsic value (e.g., "I enjoy learning math"), attainment value (e.g., "Earning a good math grade is important to me"), self-regulation (e.g., "I use strategies to ensure I learn math well"), self-efficacy (e.g., "I am confident I will do well on math assignments and projects"), utility value (e.g., "The math I learn is relevant to my life"), and test anxiety (e.g., "I am nervous about how I will do on math tests"). The final version of the MMQ consists of 30 items, each rated on a five-point Likert scale ranging from "never" to "always."

The validation process for the MMQ involved assessing face and content validity to ensure that each item accurately reflected constructs from motivation and self-regulation theories in mathematics education. The refined structure of the MMQ allows for a more precise measurement of students' motivation, addressing previous ambiguities in factor definitions. Given its strong theoretical foundation and empirical validation, the MMQ serves as a reliable tool for evaluating the motivational dimensions influencing students' engagement and achievement in mathematics.

Data Analysis Method

To answer the research questions and test the hypotheses, all collected data were analyzed using the Statistical Package for the Social Sciences (SPSS). The analysis aimed to evaluate the effectiveness of the structured digital lessons and self-assessment through success criteria in improving mathematics achievement and motivation among students in the experimental group, compared to the control group receiving traditional instruction.

Students' mathematical motivation was measured using the MMQ, which includes five-point Likert-type items categorized into key dimensions: intrinsic value, self-efficacy, utility value, self-regulation, and test anxiety. In interpreting MMQ results, student scores in each dimension were categorized using a three-level classification: low motivation (1.00–2.33), medium motivation (2.34–3.66), and high motivation (3.67–5.00). This classification was consistently applied across all motivation dimensions except for the Test Anxiety scale, for which reverse scoring was implemented. This reversal acknowledges that lower anxiety levels reflect higher motivation, thus allowing for an accurate reflection of students' overall motivational profiles.

To assess the effectiveness of the instructional intervention on students' motivation and academic achievement, One-Way Analysis of Covariance (ANCOVA) and Multivariate Analysis of Covariance (MANCOVA) were employed. The use of ANCOVA enabled control of pre-existing individual differences by statistically adjusting for pre-test scores, treating them as covariates. This allowed for more accurate estimations of the actual impact of the instructional program. Specifically, ANCOVA was applied to compare the two groups' post-test scores in academic achievement, using pre-test achievement scores as a covariate.

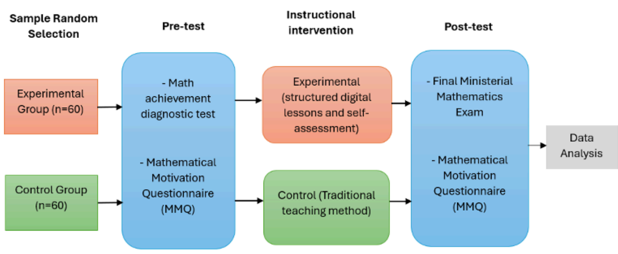
In evaluating the intervention's effect on students' motivation, MANCOVA was used to simultaneously assess the impact on all motivation dimensions, with pre-test scores in each dimension entered as covariates. Once a statistically significant multivariate effect was established, follow-up univariate ANCOVAs were conducted for each dimension separately, as well as for the overall motivation score.

All analyses were conducted at a significance level of $\alpha = 0.05$. In addition to statistical significance, the practical importance of results was assessed using effect size (η^2). According to Field's (2013) guidelines, η^2 values were interpreted as follows: small effect ($0.01 < \eta^2 < 0.06$), medium effect ($0.06 \leq \eta^2 < 0.14$), and large effect ($\eta^2 \geq 0.14$). This dual approach—examining both statistical and practical significance—provided a more nuanced understanding of the educational intervention's effectiveness on enhancing students' motivation and academic achievement in mathematics. A p-value of less than 0.05 was considered statistically significant.

To visually represent the study's methodological framework, Figure 4 below outlines the full research design process, illustrating the timeline of instrument administration and the specific intervention procedures applied to both the experimental and control groups

Figure 4

The research design process illustrating the timeline of instrument administration and intervention procedures for both experimental and control groups



Results

To answer the first research question and test the related hypothesis, a one-way ANCOVA was conducted to examine differences in post-test math achievement between the experimental and control groups after controlling for pre-test scores. Descriptive statistics and adjusted means were calculated, and effect size (η^2) was used to assess the impact of the intervention integrating structured digital lessons and self-assessment through success criteria. Table 4 below displays the pre-test, and post-test means and standard deviations for both groups, as well as the adjusted means derived from the ANCOVA analysis.

Table 4

Descriptive statistics and adjusted post-test means for mathematics achievement scores before and after the intervention (ANCOVA)

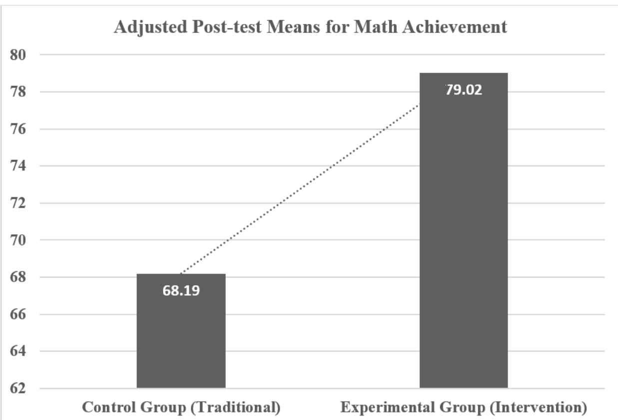
Group	*N*	Pre-test Mean	*sd*	Post-test Mean	*sd*	Adjusted Post-test Mean
Experimental (Intervention)	60	40.92	14.22	78.89	17.12	79.02
Control (Traditional)	60	39.33	15.85	68.32	22.18	68.19
Total	120	40.13	15.01	73.60	20.43	73.61

As shown in Table 4, there is a clear difference in mathematics achievement between the groups following the intervention. The experimental group, which received structured digital lessons incorporating self-assessment through success criteria, achieved a higher adjusted post-test mean (79.02) compared to the control group (68.19), suggesting that this instructional approach positively impacted students' mathematics performance. This finding supports the hypothesis that students exposed to structured digital lessons integrated with self-assessment through success criteria demonstrate significantly higher mathematics achievement than those receiving traditional instruction. It also aligns with the educational goals outlined in "We the UAE 2031" vision.

Moreover, Figure 5 below illustrates the adjusted mean scores of students in the experimental and control groups on the post-test of mathematics academic achievement after controlling for pre-test performance.

Figure 5

Comparison of adjusted post-test mean scores in mathematics achievement between the control group and the experimental group.



Accordingly, to determine whether the differences in adjusted post-test means were statistically significant, a one-way Analysis of Covariance (ANCOVA) was conducted. The results are presented in Table 5 below:

Table 5

One-way ANCOVA results for the effect of the instructional program on mathematics academic achievement

Source	Sum of Squares	*df*	Mean Square	*F*	p-value	η^2
Pre-test (Covariate)	744.243	1	744.243	1.911	0.169	0.016
Instructional intervention	3512.869	1	3512.869	9.021	*0.003	0.072
Error	45560.386	117	389.405			
Total Adjusted	49657.750	119				

*Significant at $p < 0.05$

As shown in Table 5, the ANCOVA revealed a statistically significant effect of the instructional program on students' mathematics achievement ($F = 9.021$, $p = 0.003$), after controlling for pre-test differences. The calculated effect size ($\eta^2 = 0.072$) indicates that approximately 7.2% of the variance in post-test achievement scores can be attributed to the instructional intervention. These results support the first hypothesis, confirming that structured digital lessons integrated with self-assessment through success criteria significantly enhance students' academic achievement compared to traditional instruction.

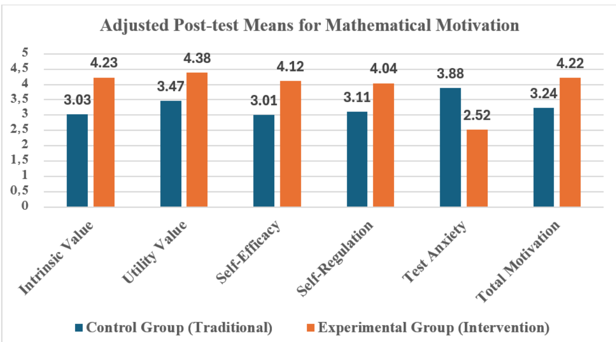
The significant improvement in students' mathematics achievement, as shown in Table 5, can be attributed to the clarity and structure provided by digital lessons integrated with self-assessment through success criteria. When students are aware of what success looks like, they are better able to monitor their progress, set specific learning goals, and engage in targeted practice (Almarode et al., 2020; López Carrillo et al., 2024). This process enhances metacognitive skills, such as self-regulation and critical thinking, enabling learners to identify gaps in their understanding and apply strategies to overcome them (Lai & Hwang, 2023; Vrieling et al., 2018). Moreover, the digital format facilitates immediate feedback and personalized support, fostering a more interactive and motivating learning environment that supports both academic growth and learner autonomy (Zare et al., 2022; Cullen et al., 2020).

To address the second research question and test the related hypothesis, a one-way MANCOVA was conducted to examine differences in mathematical motivation between the experimental and control groups across the five MMQ dimensions: intrinsic value, utility value, self-efficacy, self-regulation, and test anxiety, after controlling for pre-test scores. Descriptive statistics and adjusted means were calculated, and effect size (η^2) was used to assess the impact of the intervention integrating structured digital lessons and self-assessment through success criteria. Table 6 below presents the MANCOVA results, including the F-values, significance levels, and effect sizes for each MMQ dimension.

As shown in Table 6, the experimental group consistently outperformed the control group across all five MMQ dimensions and in total motivation. The most substantial differences appeared in self-efficacy and intrinsic value, with adjusted post-test means of 4.12 and 4.23 respectively, compared to 3.01 and 3.03 in the control group. Additionally, utility value and self-regulation also showed notable gains, with adjusted means of 4.38 and 4.04 in the experimental group, versus 3.47 and 3.11 in the control group. In contrast, test anxiety significantly decreased in the experimental group (adjusted mean = 2.52) compared to the control group (3.88), indicating a beneficial emotional outcome. These descriptive trends suggest a strong positive influence of structured digital lessons integrated with self-assessment through success criteria on students' motivational profiles in mathematics. Moreover, Figure 6 below illustrates the adjusted mean scores of students in the experimental and control groups across all MMQ dimensions as well as total motivation on the post-test of mathematical motivation, after controlling for pre-test performance.

Figure 6

Comparison of adjusted post-test mean scores in mathematical motivation dimensions between the control group and the experimental group.



To evaluate the statistical significance of the observed motivational differences, MANCOVA was conducted. Table 7 displays the MANCOVA results for the five MMQ dimensions, controlling for pre-test scores as covariates. The analysis assessed whether the intervention produced statistically significant effects on students' post-test scores in intrinsic value, utility value, self-efficacy, self-regulation, and test anxiety.

The multivariate test using Hotelling's Trace (138.211, p = 0.000) confirmed a statistically significant overall effect of the intervention across all five motivational dimensions. The univariate ANCOVA results further supported these findings, revealing statistically significant improvements in each dimension ($p < 0.05$), all favoring the experimental group. Notably, the largest effect sizes were observed for self-efficacy (η^2 = 0.165), test anxiety (η^2 = 0.157), and intrinsic value (η^2 = 0.146)—highlighting the intervention's strong influence on both cognitive and emotional components of motivation. These results underscore the effectiveness of structured digital instruction, when paired with self-assessment strategies, in fostering deeper and more sustained motivational engagement in mathematics learning.

To determine the overall impact of the intervention on students' total mathematical motivation, a one-way ANCOVA was conducted, controlling for pre-test scores. The results are presented in Table 8 below:

The ANCOVA results in Table 8 indicate a statistically significant effect of the intervention on students' total motivation (F = 377.915, p = 0.000), after accounting for baseline differences (F = 4.872, p = 0.030). The calculated effect size (η^2 = 0.764) indicates that approximately 76.4% of the variance in post-test motivation scores can be attributed to the intervention. This represents a remarkably large effect, demonstrating the substantial impact of structured digital lessons integrated with self-assessment through success criteria on enhancing students' overall motivation in mathematics. These findings provide strong empirical support for the second hypothesis and affirm the effectiveness of the intervention in fostering motivational growth.

The substantial increase in students' overall mathematical motivation, as shown in Table 8, can be attributed to the empowering effect of structured digital lessons combined with self-assessment through clear success criteria. This instructional model promotes learner autonomy, competence, and purpose—core components of intrinsic motivation (Howard et al., 2021; Almasraf, 2023). When students clearly understand expectations and are able to evaluate their progress using transparent benchmarks, they become more engaged and self-directed in their learning (Almarode et al., 2020; López Carrillo et al., 2024). Moreover, interactive digital tools provide timely, personalized feedback that boosts students' confidence, persistence, and motivation to overcome challenges (Zare et al., 2022; Cullen et al., 2020).

Table 6

Descriptive statistics and adjusted post-test means for MMQ dimensions before and after the intervention (ANCOVA)

MMQ Dimension	Group	*N*	Pre- test Mean	*sd*	Post-test Mean	*sd*	Adjusted Mean
Intrinsic Value	Experimental	60	3.02	0.61	4.25	0.48	4.23
	Control	60	2.95	0.64	3.01	0.50	3.03
Utility Value	Experimental	60	3.20	0.60	4.40	0.42	4.38
	Control	60	3.15	0.58	3.45	0.46	3.47
Self-Efficacy	Experimental	60	2.85	0.65	4.10	0.52	4.12
	Control	60	2.91	0.67	3.00	0.55	3.01
Self-Regulation	Experimental	60	2.77	0.60	4.05	0.48	4.04
	Control	60	2.83	0.62	3.10	0.51	3.11
Test Anxiety*	Experimental	60	4.20	0.75	2.50	0.59	2.52
	Control	60	4.12	0.73	3.90	0.62	3.88
Total Motivation	Experimental	60	3.24	0.49	4.21	0.38	4.22
	Control	60	3.19	0.47	3.25	0.42	3.24

Table 7

One-way MANCOVA results for the effect of the intervention on MMQ dimensions

Source	MMQ Dimension	Sum of Squares	*df*	Mean Square	*F*	p-value	η^2
Pre-test (Covariate)	Intrinsic Value	0.324	1	0.324	0.370	0.544	0.003
	Utility Value	0.218	1	0.218	0.256	0.614	0.002
	Self-Efficacy	0.189	1	0.189	0.206	0.651	0.002
	Self-Regulation	0.233	1	0.233	0.271	0.603	0.002
	Test Anxiety	0.341	1	0.341	0.384	0.537	0.003
Intervention Hotelling's Trace =138.211* *p = 0.000*	Intrinsic Value	17.341	1	17.341	19.803	0.000*	0.146
	Utility Value	14.118	1	14.118	16.129	0.000*	0.122
	Self-Efficacy	21.223	1	21.223	23.254	0.000*	0.165
	Self-Regulation	15.842	1	15.842	18.125	0.000*	0.134
	Test Anxiety	20.914	1	20.914	21.806	0.000*	0.157

*Significant at $p < 0.05$

Table 8

One-way ANCOVA results for total mathematical motivation post-test scores

Source	Sum of Squares	*df*	Mean Square	*F*	p-value	η^2
Pre-test	202.336	1	202.336	4.872	0.030	0.040
Intervention	15678.217	1	15678.217	377.915	0.000*	0.764
Error	4864.119	117	41.568			
Total Adjusted	20977.867	119				

*Significant at $p < 0.05$

Discussion

The results of the current study revealed that students in the experimental group, who were engaged in structured digital lessons combined with self-assessment through success criteria, demonstrated significantly higher academic achievement and motivation compared to their peers in the control group who received traditional instruction. The mean score difference of 10.83 in adjusted post-test mathematics achievement (experimental: 79.02, control: 68.19) underscores the effectiveness of this intervention. These findings align with previous research emphasizing the role of self-assessment and success criteria in promoting deeper learning and improved academic performance (Almasraf, 2023). When students are provided with clear success indicators and opportunities to reflect on their progress, they develop a clearer understanding of expectations and are more likely to achieve higher outcomes.

Consistent with the work of Almarode et al. (2020), the integration of success criteria supports goal setting, enables targeted feedback, and encourages students to become active participants in their learning. The significant effect size (η^2 = 0.072) further suggests that structured, student-centered approaches can meaningfully impact achievement by fostering greater self-awareness and accountability. This aligns with López Carrillo et al. (2024), who emphasize that self-assessment not only promotes critical thinking but also strengthens students' ability to monitor their learning process, leading to measurable academic gains.

Beyond academic achievement, the intervention also produced a profound effect on students' mathematical motivation. The MANCOVA results showed statistically significant differences across all five MMQ dimensions, including intrinsic value, utility value, self-efficacy, self-regulation, and test anxiety, with large effect sizes—particularly in self-efficacy (η^2 = 0.165) and test anxiety (η^2 = 0.157). These outcomes confirm that the intervention did not only support cognitive outcomes but also positively shaped students' emotional and motivational engagement. According to Lai and Hwang (2023), self-assessment fosters metacognitive skills such as self-regulation and personal goal setting, enabling learners to identify strengths and address weaknesses more effectively. This is critical for building confidence and resilience in mathematics, a subject that often challenges students' self-perception and motivation.

The ANCOVA results for total mathematical motivation (F = 377.915, p = 0.000, η^2 = 0.764) further highlight the magnitude of this impact, indicating that 76.4% of the variance in motivation could be attributed to the instructional approach. Such a remarkably high effect aligns with the literature emphasizing that when students are equipped with tools for self-evaluation and reflection, they are more engaged, focused, and motivated to improve (Sakr & Abdalla, 2024). This confirms that self-assessment strategies can transform the learning experience by promoting ownership and sustained interest, particularly when coupled with clear, achievable success criteria.

Linking these findings to "We the UAE 2031" vision, the study supports the national emphasis on fostering critical thinking, problem-solving, self-regulation, and lifelong learning skills among students. Khaled and Alghfeli (2024) highlight the importance of aligning classroom practices with broader educational objectives to prepare students for a rapidly evolving knowledge economy. By implementing instructional models that encourage self-assessment and goal-oriented learning, educators can contribute meaningfully to national goals of excellence and innovation. This approach not only enhances student performance in mathematics but also equips learners with essential competencies needed for higher education and future career success.

In conclusion, the current study demonstrates that integrating structured digital lessons with self-assessment through success criteria offers a powerful strategy for improving both academic achievement and motivation in mathematics. These findings provide robust evidence in favor of pedagogical approaches that prioritize student autonomy, reflection, and personalized feedback—elements that are critical for advancing education in line with the UAE's long-term vision for development and innovation.

Conclusion

This study concludes that integrating structured digital lessons with self-assessment through success criteria significantly enhances mathematics achievement and motivation among sixth-grade students in the UAE. The findings affirm the powerful role of self-assessment as a success-based learning strategy, offering clear advantages over traditional instructional and evaluative methods. By enabling students to monitor their progress, set personal goals, and reflect on their learning, the intervention cultivated higher levels of self-efficacy, critical thinking, and intrinsic motivation—skills essential for academic success and lifelong learning.

Moreover, the results emphasize the importance of embedding clear success criteria within digital instructional design to foster student engagement, improve metacognitive awareness, and reduce test anxiety. These outcomes are especially relevant for mathematics education, where learners often face cognitive and emotional barriers. The approach presented in this study provides educators with a practical framework for implementing formative assessment and delivering targeted, personalized feedback.

Aligned with the educational priorities of "We the UAE 2031" vision, this research highlights the value of equipping students with 21st-century skills such as self-regulation, problem-solving, and independent learning. Teachers are encouraged to adopt success criteria-driven self-assessment practices to create student-centered environments that support academic excellence, emotional resilience, and ongoing personal development. As such, this study contributes a meaningful model for educational advancement and reform in mathematics instruction at the primary level.

Recommendations and Limitations

This study recommends the integration of structured digital lessons with self-assessment through success criteria as a core instructional strategy in mathematics education. Embedding clear success criteria within digital platforms empowers students to take ownership of their learning, enhances self-regulation, and boosts academic motivation. To ensure effective implementation, teachers should receive targeted training on designing and facilitating digital learning experiences that incorporate success criteria and foster reflective student engagement. Educational institutions and policymakers are encouraged to adopt policies that support digital self-assessment frameworks, aligning with "We the UAE 2031"'s goals of promoting innovative, student-centered learning environments and cultivating future-ready skills such as autonomy, critical thinking, and lifelong learning.

While the results affirm the effectiveness of integrating structured digital lessons with self-assessment, the study is limited by its focus on a single academic subject and educational stage—sixth-grade mathematics in the UAE. The findings may not fully represent outcomes in other disciplines, age groups, or instructional settings. Additionally, the short-term nature of the intervention restricts conclusions about its long-term impact on academic achievement and motivation. Future studies should consider longitudinal designs, expand to multiple educational contexts, and explore how various digital platforms and assessment tools affect student learning to build a more comprehensive understanding of this approach's scalability and sustainability.

References

Al Murshidi, G. (2019). Stem education in the United Arab Emirates: Challenges and possibilities. *International Journal of Learning, Teaching and Educational Research*, *18*(12), 316-332. https://doi.org/10.26803/ijlter.18.12.18

Al Zarooni, K. H. (2023). *The adoption of UAE's Vision 2021 and Vision 2071 into strategic plans of private schools in the Emirate of Abu Dhabi* (Doctoral dissertation). University of Gloucestershire, Cheltenham, United Kingdom.

Alajarmeh, N., & Rashed, A. (2019). Learner in the role of instructor: promoting student peer-collaboration in learning management systems. *International Journal of Technology Enhanced Learning*, *11*(2), 121-135. https://doi.org/10.1504/ijtel.2019.098791

Aldhafeeri, F. M., & Alotaibi, A. A. (2023). Reimagining education for successful and sustainable digital shifting. *Sage Open*, *13*(1). https://doi.org/10.1177/21582440231154474

Aldosari, M. S., & Alsager, H. N. (2023). A step toward autonomy in education: probing into the effects of practicing self-assessment, resilience, and creativity in task supported language learning. *BMC psychology*, *11*(1), 434. https://doi.org/10.1186/s40359-023-01478-8.

AlKhaza'leh, M. S., Obeidat, B. F., Abdel-Hadi, S., & Al-Qaruty, R. (2023). A Future Vision for Child Education in the UAE. *Migration Letters*, *20*(7), 88-96. https://doi.org/10.59670/ml.v20i7.4261

Almarode, J., Fisher, D., Thunder, K., & Frey, N. (2020). *The success criteria playbook: A hands- on guide to making learning visible and measurable*. Thousand Oaks, CA: Corwin.

Almasraf, A. (2023). The Effectiveness of Self-assessment in Promoting Growth Mindset in EFL Students. *International Journal of Educational Researchers, 14*(4), 25-36. https://doi.org/10.29329/ijer.2023.604.3

Anthonysamy, L. (2021). The use of metacognitive strategies for undisrupted online learning: Preparing university students in the age of pandemic. *Education and Information Technologies*, 26(6), 6881-6899. https://doi.org/10.1007/s10639-021-10518-y

Badawy, H. R. (2022). *Investigating teachers' and lead teachers' perspectives on the impact of STREAM on enhancing teaching, learning, and professionalism in the Emirates Schools Establishment* (Master's thesis, United Arab Emirates University). Al Ain, United Arab Emirates: United Arab Emirates University.

Barana, A., Marchisio, M., & Sacchet, M. (2018). Advantages of Using Automatic Formative Assessment for Learning Mathematics. *Communications in Computer and Information Science*, *1*(1), 180-198. https://doi.org/10.1007/978-3-030-25264-9_12

Candel, C., Vidal-Abarca, E., Cerdán, R., Lippmann, M., & Narciss, S. (2020). Effects of timing of formative feedback in computer-assisted learning environments. *Journal of Computer Assisted Learning*, *36*(5), 718-728. https://doi.org/10.1111/jcal.12439

Chao, T., Chen, J., Star, J. R., & Dede, C. (2016). Using digital resources for motivation and engagement in learning mathematics: Reflections from teachers and students. *Digital Experiences in Mathematics Education*, *2*(3), 253-277. https://doi.org/10.1007/s40751-016-0024-6

Chiu, T. K. (2022). Applying the self-determination theory (SDT) to explain student engagement in online learning during the COVID-19 pandemic. *Journal of research on Technology in Education*, *54*(1), 14-30. https://doi.org/10.1080/15391523.2021.1891998

Christopoulos, A., Kajasilta, H., Salakoski, T., & Laakso, M. J. (2020). Limits and virtues of educational technology in elementary school mathematics. *Journal of Educational Technology Systems*, *49*(1), 59-81. https://doi.org/10.1177/0047239520908838

Cullen, C. J., Hertel, J. T., & Nickels, M. (2020, April). The Roles of Technology in Mathematics Education. *The Educational Forum*, 84(2), 166-178. https://doi.org/10.1080/00131725.2020.1698683

Dinh, C. T., & Phuong, H. Y. (2024). MOOC learners' perspectives of the effects of self-regulated learning strategy intervention on their self-regulation and speaking performance. *Cogent Education*, *11*(1), 1-24. https://doi.org/10.1080/2331186X.2024.2378497

Duangnamol, T., Supnithi, T., Srijuntongsiri, G., & Ikeda, M. (2018). Computer-Supported Meta-reflective Learning Model via mathematical word problem learning for training metacognition. *Research and Practice in Technology Enhanced Learning*, *13*(1), 1-29. https://doi.org/10.1186/s41039-018-0080-1

Eagan, T. (2023). Unlocking Student Success: The Power of Success Criteria, Relationships, and Clarity. *NECTFL Review*, *90*(1), 95-102. https://eric.ed.gov/?id=EJ1382629

Efstratopoulou, M., Opoku, M. P., Shomotova, A., Davison, C., Jaffarul, A., & Mesmar, A. (2024). In their own voices: a nationwide study of students' attitudes towards the implementation of smart learning environments in UAE schools. *Smart Learning Environments*, *11*(4), 1-22. https://doi.org/10.1186/s40561-024-00291-z

Ejubovic, A., & Puška, A. (2019). Impact of self-regulated learning on academic performance and satisfaction of students in the online environment. *Knowledge Management & E-Learning*, *11*(3), 345-363. https://doi.10.34105/j.kmel.2019.11.018

ElSayary, A. (2021). Teaching and assessing creativity in STEAM education. Journal of Systemics, Cybernetics and Informatics, 19(2), 1-7. https://doaj.org/article/1f836cf0510f412d9206aa7588c6a516

Engeness, I. (2021). Developing teachers' digital identity: towards the pedagogic design principles of digital environments to enhance students' learning in the 21st century. *European Journal of Teacher Education*, *44*(1), 96-114. https://doi.org/10.1080/02619768.2020.1849129

Field, A. (2013). *Discovering Statistics Using IBM SPSS Statistics* (4th Edition). London: Sage Publications.

Fiorella, L., Yoon, S. Y., Atit, K., Power, J. R., Panther, G., Sorby, S., ... & Veurink, N. (2021). Validation of the Mathematics Motivation Questionnaire (MMQ) for secondary school students. *International Journal of STEM Education*, *8*(52),1-14. https://doi.org/10.1186/s40594-021-00307-x

Garshasbi, A., Fathi Vajargah, K., & Arefi, M. (2019). The effect of Cooprative Learning and Self-evaluation on self motivation of students with the approach of jigsaw. *Journal of New Approaches in Educational Administration*, *10*(37), 45-68. https://doi.org/20.1001.1.20086369.1398.10.37.3.7

Glynn, S. M., Brickman, P., Armstrong, N., & Taasoobshirazi, G. (2011). Science motivation questionnaire II: Validation with science majors and nonscience majors. *Journal of research in science teaching*, *48*(10), 1159-1176. https://doi.org/10.1002/tea.20442.

Haddad, M. Z., Heong, Y. M., Razzaq, A. R. B. A., & Kiong, T. T. (2024). The UAE education reform: opportunities and challenges. *International Journal of Economics and Business Research*, *28*(3-4), 304-313. https://doi.org/10.1504/IJEBR.2024.141502

Hansen, R. (2021). The use of learning goals in mathematics education. *Scandinavian Journal of Educational Research*, *65*(3), 510-522. https://doi.org/10.1080/00313831.2020.1739125

Higgins, K., Huscroft-D'Angelo, J., & Crawford, L. (2019). Effects of technology in mathematics on achievement, motivation, and attitude: A meta-analysis. *Journal of Educational Computing Research*, *57*(2), 283-319. https://doi.org/10.1177/0735633117748416

Howard, J. L., Bureau, J. S., Guay, F., Chong, J. X., & Ryan, R. M. (2021). Student motivation and associated outcomes: A meta-analysis from self-determination theory. *Perspectives on Psychological Science*, *16*(6), 1300-1323. https://doi.org/10.1177/1745691620966789

Ikhsan, I., Hartanti, K., & Lopo, F. L. (2025). Strategies for Implementing AI in LMS to Improve the Effectiveness and Personalization of Digital Learning. *The Journal of Academic Science*, *2*(3), 944-953. https://doi.org/10.59613/qp3e7d30

Kang, G. Y. (2018). Playing with digital tools with explicit scaffolding. *The Reading Teacher*, *71*(6), 735-741. https://doi.org/10.1002/trtr.1672

Kaplar, M., Radović, S., Veljković, K., Simić-Muller, K., & Marić, M. (2022). The influence of interactive learning materials on solving tasks that require different types of mathematical reasoning. *International Journal of Science and Mathematics Education, 20*(2), 411-433. https://doi.org/10.1007/s10763-021-10151-8

Karabchuk, T., Shomotova, A., & Chmel, K. (2022). Paradox of research productivity of higher education institutions in Arab Gulf countries: The case of the UAE. *Higher Education Quarterly*, *76*(4), 759-785. https://doi.org/10.1111/hequ.12347

Karaman, P. (2024). Effects of using rubrics in self-assessment with instructor feedback on pre-service teachers' academic performance, self-regulated learning and perceptions of self-assessment. *European Journal of Psychology of Education*, *39*(3), 2551-2574. https://doi.org/10.1007/s10212-024-00867-w

Khaled, F. J. , & Alghfeli, A. S. (2024). Unlocking Potential: The Impact of Success Criteria as a Self-Assessment Strategy on Elevating Mathematics Achievement among Alkhair School Students in UAE. *Educational Administration: Theory and Practice*, *30*(8), 71-83. https://doi.org/10.53555/kuey.v30i8.7042

Kong, S. C. (2021). Delivery and evaluation of an e-Learning framework through computer-aided analysis of learners' reflection text in a teacher development course. *Research and Practice in Technology Enhanced Learning*, *16*(1), 28. https://doi.org/10.1186/s41039-021-00172-w

Lai, C. L., & Hwang, G. J. (2023). Strategies for enhancing self-regulation in e-learning: a review of selected journal publications from 2010 to 2020. *Interactive learning environments*, *31*(6), 3757-3779. https://doi.org/10.1080/10494820.2021.1943455

Li, K., Johnsen, J., & Canelas, D. A. (2021). Persistence, performance, and goal setting in massive open online courses. *British Journal of Educational Technology*, *52*(3), 1215-1229. https://doi.org/10.1111/bjet.13068

López Carrillo, M. D., Calonge García, A., & Lebrón Moreno, J. A. (2024). Self-Regulation of Student Learning in a STEAM Project. *Education Sciences*, *14*(6), 1-11. https://doi.org/10.3390/educsci14060579

Matsumoto, A. (2019). Literature review on education reform in the UAE. *International Journal of Educational Reform*, *28*(1), 4-23. https://doi.org/10.1177/1056787918824188

Moorhouse, B. L., & Wong, K. M. (2022). Blending asynchronous and synchronous digital technologies and instructional approaches to facilitate remote learning. *Journal of Computers in Education*, *9*(1), 51-70. https://doi.org/10.1007/s40692-021-00195-8

Panadero, E., & Dochy , F. (2014). Student self-assessment: assessment, learning and empowerment. *Assessment & Evaluation in Higher Education*, 39(7), 895-897. https://doi.org/10.1080/02602938.2013.871412

Panadero, E., Jonsson, A., & Botella, J. (2017). Effects of self-assessment on self-regulated learning and self-efficacy: Four meta-analyses. *Educational research review*, *22*(1), 74-98. https://doi.org/10.1016/j.edurev.2017.08.004

Puente-Díaz, R. (2012). The effect of achievement goals on enjoyment, effort, satisfaction and performance. *International Journal of Psychology*, *47*(2), 102-110. https://doi.org/10.1080/00207594.2011.585159

Raaijmakers, S. F., Baars, M., Paas, F., Van Merrienboer, J. J., & Van Gog, T. (2019). Effects of self-assessment feedback on self-assessment and task-selection accuracy. *Metacognition and Learning*, 14(1), 21-42. https://doi.org/10.1007/s11409-019-09189-5

Ran, H., Kasli, M., & Secada, W. G. (2021). A meta-analysis on computer technology intervention effects on mathematics achievement for low-performing students in K-12 classrooms. *Journal of Educational Computing Research*, *59*(1), 119-153. https://doi.org/10.1177/0735633120952063

Rao, K., Torres, C., & Smith, S. J. (2021). Digital tools and UDL-based instructional strategies to support students with disabilities online. *Journal of Special Education Technology*, *36*(2), 105-112. https://doi.org/10.1177/0162643421998327

Rehan, H. (2023). Shaping the Future of Education with Cloud and AI Technologies: Enhancing Personalized Learning and Securing Data Integrity in the Evolving EdTech Landscape. *Australian Journal of Machine Learning Research & Applications*, *3*(1), 359-395.

Robinson, J. M., & Aldridge, J. M. (2022). Environment–attitude relationships: girls in inquiry-based mathematics classrooms in the United Arab Emirates. *Learning Environments Research*, *25*(3), 619-640. https://doi.org/10.1007/s10984-022-09409-x

Ryan, R. M., Deci, E. L., Vansteenkiste, M., & Soenens, B. (2021). Building a science of motivated persons: Self-determination theory's empirical approach to human experience and the regulation of behavior. *Motivation science*, *7*(2), 97-110. https://doi.org/10.1037/mot0000194

Sakız, H., Özdaş, F., Göksu, İ., & Ekinci, A. (2021). A longitudinal analysis of academic achievement and its correlates in higher education. *Sage Open*, *11*(1). https://doi.org/10.1177/21582440211003085

Sakr, A., & Abdalla, A. M. (2024). Students' Self-Evaluation: an Empirical Study on Umm Al Quwain University Students. *Kurdish Studies*, *12*(2), 4866-4880. https://kurdishstudies.net/menu-script/index.php/KS/article/view/2613

Scheel, L., Vladova, G., & Ullrich, A. (2022). The influence of digital competences, self-organization, and independent learning abilities on students' acceptance of digital learning. *International journal of educational technology in higher education*, *19*(44), 1-33. https://doi.org/10.1186/s41239-022-00350-w

Schindler, L. A., Burkholder, G. J., Morad, O. A., & Marsh, C. (2017). Computer-based technology and student engagement: a critical review of the literature. *International journal of educational technology in higher education*, *14*(1), 1-28. https://doi.org/10.1186/s41239-017-0063-0

Schmid, R., Pauli, C., & Petko, D. (2023). Examining the use of digital technology in schools with a school-wide approach to personalized learning. *Educational technology research and development*, *71*(2), 367-390. https://doi.org/10.1007/s11423-022-10167-z

Schunk, D. H. (2023). Self-regulation of self-efficacy and attributions in academic settings. In *Self-regulation of learning and performance* (pp. 75-99). New York, NY: Routledge. https://doi.org/10.4324/9780203763353-4

Simić, K., Despotović-Zrakić, M., Bojović, Ž., Jovanić, B., & Knežević, Đ. (2016). A platform for a smart learning environment. *Facta universitatis-series: Electronics and Energetics*, *29*(3), 407-417. https://doi.org/10.2298/FUEE1603407S

Singhal, R., Kumar, A., Singh, H., Fuller, S., & Gill, S. S. (2021). Digital device-based active learning approach using virtual community classroom during the COVID-19 pandemic. *Computer Applications in Engineering Education*, *29*(5), 1007-1033. https://doi.org/10.1002/cae.22355

Sorgenfrei, C., & Smolnik, S. (2016). The effectiveness of e-learning systems: A review of the empirical literature on learner control. *Decision Sciences Journal of Innovative Education*, *14*(2), 154-184. https://doi.org/10.1111/dsji.12095

Theobald, M. (2021). Self-regulated learning training programs enhance university students' academic performance, self-regulated learning strategies, and motivation: A meta-analysis. *Contemporary Educational Psychology*, *66*, 101976. https://doi.org/10.1016/j.cedpsych.2021.101976

Van Wart, M., Ni, A., Rose, L., McWeeney, T., & Worrell, R. (2019). A literature review and model of online teaching effectiveness integrating concerns for learning achievement, student satisfaction, faculty satisfaction, and institutional results. *Pan-Pacific Journal of Business Research*, *10*(1), 1-22.

Wardat, Y., Belbase, S., Tairab, H., Takriti, R. A., Efstratopoulou, M., & Dodeen, H. (2022). The influence of school factors on students' mathematics achievements in trends in international mathematics and science study (TIMSS) in Abu Dhabi Emirate schools. *Education Sciences*, *12*(7), 424-447. https://doi.org/10.3390/educsci12070424

Xu, Z., Zhao, Y., Zhang, B., Liew, J., & Kogut, A. (2023). A meta-analysis of the efficacy of self-regulated learning interventions on academic achievement in online and blended environments in K-12 and higher education. *Behaviour & Information Technology*, *42*(16), 2911-2931. https://doi.org/10.1080/0144929X.2022.2151935

Yan, Z. (2020). Self-assessment in the process of self-regulated learning and its relationship with academic achievement. *Assessment & Evaluation in Higher Education*, 45(2), 224-238. https://doi.org/10.1080/02602938.2019.1629390

Yeh, C. Y., Cheng, H. N., Chen, Z. H., Liao, C. C., & Chan, T. W. (2019). Enhancing achievement and interest in mathematics learning through Math-Island. *Research and Practice in Technology Enhanced Learning*, *14*(1),1-19. https://doi.org/10.1186/s41039-019-0100-9

Yıldızlı, H., & Saban, A. (2016). The effect of self-regulated learning on sixth-grade Turkish students' mathematics achievements and motivational beliefs. *Cogent Education*, *3*(1), 1-17. https://doi.org/10.1080/2331186x.2016.1212456

Yorganci, S. (2025). The impact of synchronous online discussions and online flipped learning on student engagement and self-regulation among preliminary undergraduates in a basic math course. *Educational technology research and development*,*1*(1) 1-32. https://doi.org/10.1007/s11423-025-10459-0

Zare, A., Heidari, H., Davoodi, H., & Moeini Kia, M. (2022). Modeling self-assessment impact on math achievement with mediated by self-regulation and self-efficacy of high school students. *Journal of School Psychology and Institutions*, *11*(2), 62-70. https://doi.org/10.22098/jsp.2022.1717

Zeide, E. (2017). The structural consequences of big data-driven education. *Big Data*, *5*(2), 164-172. https://doi.org/10.1089/big.2016.0061

Zhang, L., Jackson, H. A., Hunt, T. L., Carter Jr, R. A., Yang, S., & Emerling, C. R. (2022). Maximizing learning management systems to support mathematical problem solving in online learning. *Teaching Exceptional Children*, *54*(3), 192-201. https://doi.org/10.1177/0040059921996730.

Zhang, M., Trussell, R. P., Gallegos, B., & Asam, R. R. (2015). Using math apps for improving student learning: An exploratory study in an inclusive fourth grade classroom. *TechTrends*, *59*(2), 32-39. https://doi.org/10.1007/s11528-015-0837-y

Zhu, M., Bonk, C. J., & Doo, M. Y. (2020). Self-directed learning in MOOCs: Exploring the relationships among motivation, self-monitoring, and self-management. *Educational Technology Research and Development*, *68*(1), 2073-2093. https://doi.org/10.1007/s11423-020-09747-8.

Zimmerman, B. J., & Schunk, D. H. (2013). *Self-regulated learning and academic achievement: Theoretical perspectives*. New York, NY :Routledge. https://doi.org/10.4324/9781410601032