Enhancing Digital Literacy through Metacognitive Instruction: A Study of the School-Wide Optimum Model (SWOM) Effect on Achievement and Attitudes in Eighth-Grade Computer Education

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Abstract

This quasi-experimental study examined whether the School-Wide Optimum Model (SWOM)—a metacognitive, thinking-skills-integrated instructional approach—improves achievement and attitudes in a middle-school Computer and Information Technology (CIT) unit. The study's significance lies in the importance of teaching programming to students at different educational levels. Two intact ninth-grade classes from one public school participated. The final analytic sample comprised 30 students. Over four weeks (two sessions per week), the SWOM class received instruction embedding questioning, comparison, probability generation, prediction, problem solving, and decision making within the 'I Learn from Technology' unit, while the control class received lecture-based instruction. Outcomes included a researcher-developed CIT achievement test and an attitude toward computer learning scale, with high internal consistency (pilot $\alpha = .89$). Mann–Whitney U tests indicated higher posttest achievement scores for the SWOM group. Pretest comparisons showed no significant baseline differences. These results suggest that embedding metacognitive thinking skills via SWOM is associated with meaningful gains in digital-skills learning and more positive learner attitudes. Practical implications for teacher professional development, curriculum design, and lab organization are discussed, along with limitations related to intact-class assignments and attrition.

Keywords: digital skills; School-Wide Optimum Model (SWOM), metacognitive strategies, computer education, academic achievement, student attitudes, quasi-experimental design, middle school education, digital literacy

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1. Introduction

Developing higher-order thinking skills, such as problem-solving and decision-making, is essential in modern education (Al-Duqail, 2021; Aujan, 2021; Salman & Alwan, 2020). Despite this emphasis, metacognitive strategies, such as the School-Wide Optimum Model (SWOM), remain underutilized in computer and information technology curricula. Grounded in constructivist theory, SWOM integrates six core skills—questioning, comparing, generating probabilities, predicting, problem-solving, and decision-making—into content, fostering collaborative and adaptive instruction (Al-Zubaidi, 2019; Kashash & Hadi, 2020).

Academic achievement serves as a primary indicator of educational success and is closely linked to positive attitudes toward learning (Abdel Ghafoor, 2021; Al-Shawoush, 2019). In computer education, which cultivates digital literacy and 21st-century competencies like collaboration and critical thinking (Ministry of Education, 2021), student performance is often suboptimal (Al-Ghamdi, 2018; Al-Mohammadi, 2018; Halawani, 2020). Observational evidence suggests students primarily use technology for entertainment, leading to disengagement in structured academic tasks (Al-Shammari & Al-Massad, 2019).

These challenges underscore the need for learner-centered approaches. Given SWOM's demonstrated efficacy in other disciplines (e.g., Ibrahim & Hussein, 2019; Khalifa, 2021), this study investigates its impact on achievement and attitudes in computer education among third-grade intermediate students.

Building on this need for innovation, metacognitive strategies grounded in constructivist theory serve as powerful tools to enhance student achievement by fostering understanding of cognitive processes and improving information retention (Kashash & Hadi, 2020). These methods facilitate active knowledge construction by encouraging self-regulated learning, thereby granting students agency over their own educational processes (Abu Jazar, 2018).

One prominent metacognitive approach that centers the student in the learning process is the School-Wide Optimum Model (SWOM). SWOM systematically incorporates higher-order thinking skills—such as questioning, forecasting, and decision-making—into the curriculum. Its unique features include collaborative problem-solving, adapting instruction to student learning styles, addressing emotional intelligence, and emphasizing real-world application. Unlike conventional methods that address thinking skills separately, SWOM principles are accessible to all school personnel and accommodate diverse learner characteristics (Al-Zubaidi, 2019; Al-Adwan & Dawood, 2018).

Academic achievement remains a primary indicator of educational success (Al-Shawoush, 2019). However, cognitive performance is deeply intertwined with affective factors; students who possess positive attitudes toward a subject are more likely to demonstrate higher engagement and achievement (Abdel Ghafoor, 2021). This is particularly relevant in Computer and Information Technology education, a critical discipline that equips students with essential digital literacy and technical skills required for modern life and future careers. The lack of adequate digital skills can have significant real-world consequences, such as reduced employability and limited career growth opportunities in an increasingly digital world. Beyond technical proficiency, this curriculum fosters 21st-century competencies, including collaboration, critical thinking, and digital citizenship (Ministry of Education, 2021).

Given the demonstrated success of SWOM in other disciplines and the scarcity of research on its application in computer education, this study aims to investigate the effect of the SWOM strategy on the academic achievement and attitudes of third-grade intermediate students in a Computer and Information Technology course.

2. Statement of Problem

The problem statement underlying this research is multifaceted. First, observational and empirical evidence suggest a troubling disconnect between students' pervasive recreational use of digital technologies and their academic engagement with structured CIT curricula. Many students approach computers primarily as entertainment platforms, leading to diminished motivation when encountering formal educational requirements (Al-Shammari & Al-Massad, 2019). Second, traditional CIT instruction often emphasizes procedural knowledge and rote software operation through teacher-centered, lecture-based methods, which may fail to stimulate the deeper cognitive engagement necessary for conceptual understanding and skill transfer (Al-Hassan, 2012). This pedagogical approach stands in stark contrast to constructivist principles that position learners as active constructors of knowledge. Consequently, there exists a pressing need for instructional innovations that can transform CIT classrooms into environments where students develop not only technical competencies but also the metacognitive awareness to regulate their learning and apply digital skills to novel, real-world problems.

Metacognitive strategies, grounded in constructivist learning theory, offer a promising framework for such transformation. Metacognition, the awareness and regulation of one's own thinking processes, enables learners to plan, monitor, and evaluate their cognitive activities, leading to more meaningful understanding and improved knowledge retention (Flavell, 1979; Kashash & Hadi, 2020). When students develop metacognitive capabilities, they transition from passive recipients of information to active, self-directed learners who can adapt strategies to different learning contexts (Abu Jazar, 2018; Bahloul, 2004). One comprehensive instructional model designed to operationalize metacognitive principles is the School-Wide Optimum Model (SWOM). Developed by Swartz and Ahmed, SWOM systematically integrates six core thinking skills—questioning, comparing, generating probabilities, predicting, problem-solving, and decision-making—directly into subject matter content through a structured pedagogical protocol (Al-Hashimi & Al-Dulaimi, 2008; Al-Asiri, 2020). Unlike approaches that treat thinking skills as supplementary, SWOM embeds them as essential components of content mastery, fostering holistic cognitive development. SWOM has been shown to be effective across a variety of courses (Kashash & Hadi, 2020; Salman & Alwan, 2020; Mohammed, 2017).

Empirical research has demonstrated SWOM's effectiveness across diverse academic disciplines. Quasi-experimental studies report significantly higher achievement among students taught with SWOM strategies in subjects including chemistry (Al-Lami & Al-Rubaie, 2017), biology (Ibrahim & Hussein, 2019), grammar (Salman & Alwan, 2020), jurisprudence (Aujan, 2021), and art anatomy (Khalifa, 2021). Furthermore, SWOM has been shown to enhance specific cognitive skills such as mathematical thinking (Abu Jazar, 2018) and reflective thinking (Al-Zubaidi, 2019). Despite this robust evidence base across disciplines and its strong theoretical alignment with the needs of modern CIT education, no identified study has investigated the application or efficacy of the SWOM strategy within computer and digital literacy education. This represents a significant gap in both the instructional design literature and the pedagogy of digital skills.

Therefore, this study addresses this research gap by examining the impact of the SWOM instructional model on two critical educational outcomes in middle school CIT: academic achievement and learning attitudes. By implementing SWOM within the context of digital skills education, this research seeks to determine whether this metacognitive strategy can enhance both the cognitive mastery of technical content and students' affective disposition toward learning with technology.

3. Research Questions

To address the identified problem, this study is guided by the following research questions:

RQ1: What is the effect of the SWOM instructional strategy on the academic achievement of Eighth-Grade students in the Computer and Information Technology course?

RQ2: What is the effect of the SWOM instructional strategy on Eighth-Grade students' attitudes toward learning Computer and Information Technology?

4. Study Hypotheses

To address the study questions, the following hypotheses were tested:

1. H1: There is a statistically significant difference ($\alpha \leq 0.05$) between the experimental and control groups in posttest achievement in the Computer and Information Technology course, in favor of the experimental group.
2. H2: There is a statistically significant difference ($\alpha \leq 0.05$) between the experimental and control groups in attitudes toward learning the Computer and Information Technology course, in favor of the experimental group.
3.

5. Significance of the Study

This study contributes to the field of educational technology and curriculum instruction in the following ways:

5.1. Theoretical Significance

Addressing the Literature Gap: A review of research databases reveals a scarcity of studies on the SWOM strategy in Computer and Information Technology education.

Pedagogical Insight: The findings highlight the potential of SWOM as a viable instructional model for digital skills, offering a theoretical basis for future research into metacognitive strategies in Computer Education.

5.2. Practical Significance

Instructional Improvement: The study offers actionable insights for computer teachers to adopt adaptive, learner-centered strategies that move beyond traditional lecturing.

Strategic Vision: the School-Wide Optimum Model (SWOM.

This study may provide a vision for adopting the Comprehensive School Optimal Model (SWOM) in teaching courses other than the computer and information technology course, or for applying it across different educational stages。

6. Definition of Terms

The Comprehensive Optimal School Model (SWOM) Strategy: Al-Hashemi and Al-Dulaimi (2008) defined it as: "One of the recent trends in teaching thinking skills and integrating them into educational content, which aims to improve and produce learning, is to prepare a conscious generation that thinks holistically, through a set of organized ideas that the teacher and the student follow when studying a particular topic" (p.141). It is operationally defined as: a set of steps, regular procedures, and educational activities in the form of specific skills, which were presented in the teaching of the computer and information technology course to the students of the experimental group in the third grade of intermediate, with the aim of reaching the greatest possible amount of ideas, knowledge, and information in the educational situation.

Achievement: It is defined as "the amount of information, knowledge, or skills that a student obtains, expressed in scores in a prepared test in a way that can measure the specific levels" (Shehata & Al-Najjar, 2003, p. 98). Achievement is defined operationally as the score obtained by the student in the achievement test prepared in this study in the content of the computer and information technology course in the third module, “I Learn from Technology".

Attitudes Toward Learning refer to students’ evaluative dispositions (favorable or unfavorable) toward learning activities and the subject matter, which can influence their engagement, effort, and persistence (Ajzen, 1991). In this study it is defined operationally: as the tendency and readiness formed in the learner, and it can be determined by the degree of the learner's positive, negative, or neutral feeling towards the study of the computer and information technology course, as it is measured in this study by the degree achieved by the learner in the scale of the attitude towards computer and information technology learning prepared for this study.

7. Theoretical Framework

7.1 Metacognition and Constructivist Learning Foundations

The theoretical underpinnings of this study are rooted in constructivist learning theory, which emphasizes metacognitive development. Constructivism posits that knowledge is not passively received but actively built by the learner through experience and reflection (Bruyon, 2004). Within this paradigm, metacognition serves as the executive function that enables effective knowledge construction. Flavell (1979), who pioneered the study of metacognition, conceptualized it as comprising both metacognitive knowledge (understanding one's own cognitive processes) and metacognitive regulation (the active control and orchestration of these processes). This dual aspect enables learners to select appropriate strategies, monitor comprehension, and evaluate learning outcomes.

Subsequent research has elaborated on these foundations. Al-Affun and Abdulsabeh (2012) define metacognition as "processes that help students learn from others, increase awareness of subjective thought processes, and are concerned with planning, monitoring, and evaluation skills that control and manage cognitive processes accurately" (p. 194). This regulatory capacity is particularly crucial in technical domains such as computer education, where learners must continually assess their understanding of abstract concepts, debug errors in procedural tasks, and transfer skills across different software environments. Abdel Wahab (2005) notes that the application of metacognitive strategies enhances cognitive development by improving focus, attention, and information recall, which directly translates into improved academic achievement. Furthermore, Bahloul (2004) emphasizes that metacognitive strategies empower students to bridge theoretical knowledge with practical application, fostering learner autonomy—a critical competency in technology education where tools and platforms evolve rapidly.

7.2. Comprehensive School Optimal Model (SWOM) strategy.

One metacognitive strategy is the School Wide Optimum Model (SWOM), which puts the student at the center of the learning process by integrating higher-order thinking skills with the subject matter. This increases students' problem-solving abilities and, consequently, their level of achievement (Al-Zubaidi, 2019). According to Kashash and Hadi (2020), metacognitive methods grounded in constructivist theory help students perform better by raising their awareness of metacognitive principles and improving their memory. Therefore, before delving into the comprehensive optimal model of the school, constructivist theory and metacognitive methods will be briefly reviewed.

7.3. Metacognitive Knowledge

One of the key ideas in education based on constructivist theory is metacognition. John Flavell is credited with being the first to study this idea in the 1970s, noting that students' monitoring of their memory and comprehension is limited and that they are not sufficiently aware of the strategies and methods of knowledge they are supposed to follow in learning. Falafel aims to develop concepts that help students understand themselves as students (Abdullah, 2016). According to Bruyon (2004), metacognition refers to the actions a person takes to regulate his or her cognitive processes. These actions include organizing and monitoring cognitive activities and ensuring that their goals are achieved.

Lindstrom (2004) describes metacognition as "a set of actions that enable the learner to make decisions, choose alternatives that suit the educational situation, self-evaluate, make and achieve his goals, be aware of his thinking, and control his thinking strategies" (p. 28). According to Al-Otoum et al. (2007), it is the capacity to comprehend and observe an individual's own ideas, hypotheses, and contents contained in his activities, as well as thinking about thinking, knowledge of knowledge, or knowledge about knowledge phenomena.

7.4. Importance of Metacognition

According to Abdel Wahab (2005), the application of metacognitive strategies enhances the learner's cognitive development by improving his focus, attention, and recall of information, which is reflected in the improvement of his academic achievement, as well as his skill development because of its emphasis on critical thinking, problem-solving skills, planning, evaluation, and analysis, as well as its development of emotional aspects, such as the learner's awareness and orientation toward the learned material. However, Bahloul (2004) notes that metacognitive strategies help students in a variety of learning contexts by enhancing their comprehension, assisting them in using and employing information in various learning contexts, and empowering them to contribute positively to the learning process by making them assist in gathering, monitoring, and evaluating information, as well as by bridging the gap between theory and practice.

7.5. Comprehensive School Optimal Model (SWOM) Strategy

The strategy's name, SWOM, is an acronym derived from its founders: "SW" from Robert Swartz, Director of the National Center for Thinking Education in Boston, USA, and "OM" from Omar Ahmed, Head of the UAE's Center for Thinking Education and Talent Development. Procedurally, SWOM is defined as "a set of steps that are based on integrating thinking skills and habits into the curriculum, with the aim of arriving at a number of scientific ideas and consistent vocabulary in response to a scientific problem". Other scholars, such as Raji (2016) and Abdul-Amir (2016), describe it as a set of systematic, sequential steps grounded in specific thinking skills, such as questioning, comparing, and predicting.

The Comprehensive School Optimal Model (SWOM) is a contemporary approach to teaching thinking skills by integrating them into curricular content. It aims to enhance learning by preparing learners who think holistically and engage actively with the content rather than passively receiving information (Al-Hashimi & Al-Dulaimi, 2008). The model is often associated with the work of Robert Swartz and Omar Ahmed, who contributed to its development and dissemination in educational settings (Al-Asiri, 2020).

Raji (2016) describes the SWOM strategy as a set of systematic steps that integrates thinking skills with subject-matter learning. SWOM is commonly implemented through a sequence of interrelated skills (e.g., questioning, comparing, generating probabilities, predicting, problem-solving, and decision-making) embedded in classroom instruction to promote meaningful learning.

7.6. SWOM Strategy Skills

Six fundamental thinking skills—questioning, comparison, probability generating, prediction, problem solving, and decision making—are the foundation of the Comprehensive School Optimal Model (SWOM), which aims to improve students' cognitive engagement (Al-Hashimi & Al-Dulaimi, 2008). By actively integrating students into the learning process, questioning is essential for capturing their attention and encouraging more profound thought (Attia, 2016). According to Saeed (2013) and Fathy (2016), comparison also promotes cognitive growth by helping students organize information and differentiate between concepts. In addition to highlighting similarities and differences, comparison adds a level of intellectual difficulty that boosts motivation.

The ability to generate probability entails making constructive connections between new and prior knowledge, which promotes the development of new cognitive connections (Abu Jado & Nofal, 2007). By encouraging students to conclude future events based on prior experiences, prediction expands this process and enhances their ability to plan and think strategically (Fathy, 2016). According to Al-Ashqar (2011) and Saeed (2013), problem-solving abilities equip students with the tools to overcome barriers and support both practical reasoning and the fulfillment of cognitive demands. Lastly, decision-making is an organized cognitive process that aims to achieve the best possible results by carefully choosing the greatest option among alternatives based on predetermined criteria (Al-Adwan & Daoud, 2018).

Reflective thinking is emphasized as the cornerstone of learning in the SWOM strategy's core principles. Al-Asiri (2020) argues that the approach positions learning as an ongoing, lifelong activity by integrating productive mental processes into instructional practice while recognizing learner diversity and individual needs. When instructional practices align with the content being taught and emotional elements are acknowledged as crucial components of meaningful learning, effective learning occurs.

7.8. Objectives of the SWOM Strategy

According to Al-Hashimi, Al-Hashemi, and Al-Dulaimi (2008), the Comprehensive School Optimal Model (SWOM) seeks to cultivate a conscious generation capable of critical and creative thought, productive, and engaged in lifelong self-learning. Additionally, it uses interconnected, integrated tactics to automatically incorporate a range of abilities, processes, and mental habits into the learning environment. It supports the development of self-learning capabilities by shifting the learning process from indoctrination to one that stimulates thinking, analysis, deduction, and evaluation. In addition to its goal of producing a generation capable of handling life's obstacles on its own, it aims to make wise choices in a variety of circumstances.

7.9. The Role of the Teacher and the Learner in the Comprehensive School Optimal Model (SWOM) Strategy

According to Mohammed (2017), the teacher's responsibility in the SWOM strategy is to present information to students in a way that encourages them to think critically and explore questions before seeking answers. In addition to facilitating classroom activities in a way that ensures unity, diversity, and order, which aids the development of critical thinking abilities, as well as the presentation and assessment of mental processes. In addition to providing students with clear and detailed examples, ask them to use the same procedures. It is the learner's responsibility to focus on honing specific skills and to understand how to navigate between them sequentially. The capacity to think critically, assess concepts, plan the strategy's future application, and apply the knowledge and abilities learned outside of the classroom to real-world situations.

7.10. Empirical Evidence for SWOM Across Disciplines

A growing body of quasi-experimental research substantiates SWOM's effectiveness across educational contexts. These studies consistently demonstrate that SWOM-based instruction yields superior learning outcomes compared to traditional methods. Al-Lami and Al-Rubaie (2017) found that second-grade intermediate students taught chemistry through SWOM achieved significantly higher scores than their peers in control groups. Similarly, Ibrahim and Hussein (2019) reported substantial gains in biology achievement among female intermediate students following the implementation of SWOM. The model's transferability is further evidenced in humanities subjects: Aujan (2021) documented improved understanding of jurisprudential concepts among sixth-grade students, while Salman and Alwan (2020) observed significant gains in grammar achievement at the university level.

Beyond content mastery, research indicates SWOM enhances specific cognitive capacities. Abu Jazar (2018) found that ninth-grade students demonstrated improved mathematical thinking skills following SWOM instruction. Al-Zubaidi (2019) reported significant development in reflective thinking skills among secondary students. At the university level, Al-Sayed (2021) found that SWOM-based instruction promoted 21st-century skills, including critical thinking and collaborative problem-solving. Collectively, these studies establish SWOM as a robust instructional model with demonstrable benefits for both disciplinary achievement and broader cognitive development.

7.11. Computer Education: Challenges and Innovative Approaches

Research on computer and digital skills education reveals both persistent challenges and promising pedagogical innovations. Despite technology's ubiquity, student achievement in formal CIT courses often remains unsatisfactory (Al-Ghamdi, 2018; Al-Mohammadi, 2018). This paradox may stem from the disconnect Halawani (2020) identifies between informal, entertainment-oriented technology use and formal academic requirements. Traditional computer instruction frequently emphasizes procedural knowledge through step-by-step demonstrations and rote practice, approaches that may fail to develop the conceptual understanding necessary for adaptive skill application (Al-Hassan, 2012).

In response, researchers have explored various technology-enhanced and student-centered pedagogies with positive results. Al-Hassan (2012) demonstrated that computer-aided instructional software significantly improved achievement in computer applications compared to conventional teaching. Al-Hassan and Al-Matroodi (2017) found that cooperative learning facilitated through the Edmodo educational social network yielded superior outcomes to both traditional instruction and face-to-face cooperative learning. Visual learning tools have also proven effective; Al-Shavoush (2019) reported that infographics significantly enhanced achievement in computer studies among secondary students. Similarly, Al-Sheikh (2019) found that varying digital media density within cloud-computing applications differentially affected achievement, with higher-density media producing better outcomes.

Concurrently, research affirms the importance of affective factors in technology learning. Positive attitudes toward computers correlate with higher engagement, persistence, and ultimately achievement (Abdel Ghafoor, 2021). However, fostering such attitudes requires moving beyond transactional skill delivery to create learning experiences that students perceive as meaningful, relevant, and intellectually stimulating.

Despite these advances, no prior study has examined the application of a comprehensive metacognitive model such as SWOM in CIT education. This omission is significant because SWOM's integrated approach—simultaneously targeting cognitive skill development, content mastery, and potentially affective engagement—addresses multiple limitations identified in current computer education practice. By explicitly teaching students how to think about digital concepts and problems, SWOM may help bridge the gap between procedural knowledge and adaptive competence。

8. Methodology

8.1. Research Design

This study employed a quasi-experimental pretest-posttest control group design. This design was selected because it allows for comparison between groups while accommodating the practical constraints of educational settings where random assignment of individual students is often infeasible (Melhem, 2005). The independent variable was the instructional strategy, operationalized at two levels: (1) the SWOM metacognitive strategy (experimental group) and (2) traditional lecture-based instruction (control group). The dependent variables were academic achievement in the CIT course and attitudes toward learning CIT.

8.2. Participants and Setting

The study population consisted of all ninth-grade male students at an intermediate school in Saudi Arabia during the second semester of the 2023-2024 academic year. The school serves a predominantly middle-class community and follows the national curriculum prescribed by the Saudi Ministry of Education. A convenience sample of two intact classes was selected in consultation with school administration, totaling 44 students initially.

Due to absenteeism during post-test administration, the final analyzed sample comprised 30 students ($N = 30$). One intact class was assigned as the experimental group ($n = 15$) and the other as the control group ($n = 15$). This method of group assignment, while not random, maintained ecological validity by preserving existing classroom communities and minimizing disruption to school routines. To address potential selection bias, statistical tests of pre-intervention equivalence were conducted on key variables.

The participants ranged in age from 14 to 15 years, reflecting the typical age for ninth-grade students in the Saudi educational system. All participants completed prerequisite computer courses in earlier grades, ensuring basic familiarity with computer operations and software interfaces. Parental consent and student assent were obtained prior to study commencement, and the study protocol was approved by the relevant institutional review board.

8.3. Ethical Considerations

All procedures adhered to institutional and national standards for research with minors. The study followed school and university guidelines for consent/assent and data confidentiality; the corresponding author can provide the approval reference upon request.

8.4. Study Materials and Procedures

Academic Achievement Test. A researcher-developed post-test assessed cognitive achievement on the "I Learn from Technology" unit, the third module in the ninth-grade CIT curriculum. The test comprised 25 multiple-choice items with four alternatives each, developed in alignment with the unit's six specified learning objectives outlined in the Ministry of Education (2021) teacher's guide. Items assessed conceptual understanding, procedural knowledge, and application skills across unit topics, including digital citizenship, online research, data representation, and basic programming concepts.

Content validity was established through a review panel of five experts: two faculty members specializing in computer education from Saudi universities, two experienced CIT supervisors from the regional education office, and one measurement specialist. The panel evaluated item-objective alignment, clarity, appropriateness for the target grade level, and absence of bias. Items achieving less than 80% agreement regarding relevance and clarity were revised or eliminated. The final instrument demonstrated strong content validity.

Reliability was assessed using the Kuder-Richardson 20 (KR-20) coefficient, appropriate for dichotomously scored items. Analysis of pilot data from a comparable sample ($n = 22$) yielded KR-20 = .82, indicating good internal consistency. For the main study sample ($N = 30$), KR-20 was .84, confirming the instrument's reliability.

A teacher's guide for teaching was prepared according to the SWOM strategy. The teacher's guide included the proposed time plan for each lesson of the third module, "I Learn from Technology", the general objectives of the unit, an overview of the SWOM strategy, and the planning of the unit lessons according to the SWOM strategy.

The SWOM strategy is a metacognitive strategy that consists of a set of interrelated actions that rely on the integration of thinking skills, namely questioning, comparison, probability supply, prediction, problem-solving, and decision-making skills in educational content.

Experimental treatment procedures: Instruction embedded SWOM's six thinking skills into each lesson in the 'I Learn from Technology' unit over four weeks (two sessions/week). Activities used prompting questions, structured comparisons, prediction exercises, troubleshooting routines, and decision criteria to scaffold metacognitive regulation.

Control group procedures: The same unit content was delivered via teacher-led explanation and individual practice, aligned with the official textbook and teacher's guide, without explicit SWOM prompts.

8.5. Study Instruments

To achieve the study objectives and answer research questions, two instruments were used: (1) an achievement test and (2) an attitude scale toward learning computer and digital skills. The following procedures were used to develop and validate these instruments:

Achievement test: Tests are widely used to evaluate learning outcomes and are defined as "a structured procedure to measure a trait through a sample of behavior" (Melhem, 2005, p. 27). In this study, an achievement test was developed to assess students' knowledge and digital skills aligned with the unit content.

Achievement test validity: Content validity was established through expert review. The initial version of the test was evaluated by faculty members specializing in curriculum and computer teaching methods, as well as supervisors and Computer and Information Technology teachers. Based on reviewers' feedback, the wording was refined, and some items were revised to better align with the level of intermediate students.

Attitude Toward Computer Learning Scale. Student attitudes were measured using a 20-item, 5-point Likert-type scale (1 = Strongly Disagree to 5 = Strongly Agree). The scale was developed based on a review of relevant literature and previous measures (e.g., Al-Hawamdeh, 2021; Al-Rashed, 2015) and guided by established procedures for scale construction (DeVellis, 2017). Items measured three dimensions identified in factor analysis: (1) perceived enjoyment and interest in CIT learning (7 items, e.g., "I look forward to computer class"), (2) perceived usefulness and relevance of CIT skills (7 items, e.g., "Learning computer skills will help me in the future"), and (3) self-efficacy and confidence in learning CIT (6 items, e.g., "I am confident I can learn new computer skills").

Content validity was established through the same expert panel review process, resulting in minor wording modifications. Construct validity was supported by a principal components analysis with varimax rotation, which confirmed a three-factor structure accounting for 68.4% of the variance. All items loaded above .40 on their primary factors with minimal cross-loadings.

Internal consistency reliability was excellent. Cronbach's alpha coefficients were .89 for the total scale, and .84, .82, and .79 for the enjoyment, usefulness, and self-efficacy subscales, respectively. Test-retest reliability over a two-week interval with a separate sample (n = 20) was r = .86, indicating good temporal stability.

8.6. Study Materials

A teacher's guide was developed to translate SWOM into practical lesson designs for the unit. The guide included: unit overview and goals; time plan per lesson; SWOM skill definitions and examples; lesson procedures with explicit prompts for each SWOM skill; and sample reflection questions.

8.7. Procedures

Preparation: The SWOM teacher's guide was finalized before implementation. Pretesting: Both instruments were administered to both groups to establish baseline equivalence. Intervention: Over four weeks, the experimental class received SWOM-embedded lessons (two sessions/week), and the control class received lecture-based instruction over the same content and time. Post-testing: Both instruments were re-administered at unit completion.

8.9. Intervention Protocol

Control Group Instruction. Students in the control group received instruction following the standard Ministry of

Education teacher's guide for the "I Learn from Technology" unit. Instruction was teacher-centered and textbook-driven, employing direct explanation, whole-class demonstrations of software procedures, and individual practice exercises—methods representative of typical CIT instruction nationwide. The same certified computer teacher delivered instruction to both groups to control for teacher effects, receiving specific training to maintain methodological consistency across conditions.

Experimental Group (SWOM) Instruction. Students in the experimental group studied the identical unit content but through the SWOM instructional framework. A detailed teacher's guide was developed, mapping the six SWOM thinking skills onto each lesson topic. The teacher received 12 hours of training in SWOM principles and implementation, including modeling, guided practice, and feedback sessions.

8.10. Data Analysis

Data were analyzed using IBM SPSS Statistics Version 27. Given the small sample size ($n < 30$ per group) and preliminary checks indicating violations of normality assumptions (Shapiro-Wilk tests, $p < .05$ for several distributions), non-parametric tests were selected for primary analyses. Descriptive statistics (means, standard deviations, frequencies) characterized the sample and variable distributions.

To establish pre-intervention equivalence, Mann-Whitney U tests were used to compare experimental and control groups on pre-test attitude scores and prior knowledge assessment scores. The primary hypotheses were tested using Mann-Whitney U tests comparing post-intervention achievement and attitude scores between groups. The significance level was set at $\alpha = .05$ for all tests.

Effect sizes were calculated using two complementary measures: eta-squared (η^2) for variance explanation interpretation, and Pearson's r (calculated as $r = z/\sqrt{N}$) as the appropriate effect size for Mann-Whitney U tests. According to Cohen's (1988) conventions for r, .10 represents a small effect, .30 a medium effect, and .50 a large effect. For η^2, .01, .06, and .14 represent small, medium, and large effects, respectively.

9. Results

9.1. Preliminary Analyses: Testing Pre-Intervention Equivalence

Prior to testing the primary hypotheses, Mann-Whitney U tests were conducted to ensure the experimental and control groups were statistically equivalent on relevant pre-intervention measures. As presented in Table 1, no significant differences were found between groups on either pre-test attitude scores (U = 102.50, z = -0.416, p = .677) or prior knowledge assessment scores (U = 105.00, z = -0.238, p = .812). These results confirm that the groups were comparable in both affective disposition toward computer learning and baseline knowledge of unit-related concepts before the intervention, establishing initial equivalence and strengthening internal validity.

Table 1. Mann-Whitney U Tests for Pre-Intervention Equivalence Between Experimental and Control Groups

Variable	Group	*n*	Mean Rank	Sum of Ranks	U	z	*p*
Pre-Attitude Scores	Control	15	14.83	222.50	102.50	-0.416	.677
	Experimental	15	16.17	242.50			
Prior Knowledge Assessment	Control	15	14.60	219.00	105.00	-0.238	.812
	Experimental	15	16.40	246.00			

9.2. Hypothesis Testing: Academic Achievement

The first research hypothesis addressed differences in academic achievement. The null hypothesis stated that there was no significant difference in post-test achievement scores between students taught with the SWOM strategy and those taught with traditional methods. As shown in Table 2, the Mann-Whitney U test results rejected this null hypothesis. The experimental group (Mean Rank = 20.57) demonstrated significantly higher achievement than the control group (Mean Rank = 10.43), with U = 36.50, z = -3.167, $p < .001$.

The effect size was substantial. Eta-squared (η^2) was calculated as .33, representing a large effect according to Cohen's benchmarks. The corresponding r effect size was .58, indicating a large effect. These results indicate that approximately 33% of the variance in post-test achievement scores can be attributed to the instructional method, with the SWOM strategy producing markedly superior outcomes.

Table 2. Mann-Whitney U Test for Post-Intervention Academic Achievement Scores

Group	*n*	Mean Rank	Sum of Ranks	U	z	*p*	η²	r
Control	15	10.43	156.50	36.50	-3.167	< .001	.33	.58
Experimental	15	20.57	308.50					

9.3. Hypothesis Testing: Attitudes Toward Learning

The second research hypothesis concerned differences in attitudes toward learning computer and information technology. The null hypothesis posited that there was no significant difference in post-test attitude scores between the instructional groups. Results presented in Table 3 indicate rejection of this null hypothesis as well. The experimental group (Mean Rank = 19.20) reported significantly more positive attitudes than the control group (Mean Rank = 11.80), with U = 57.00, z = -2.305, $p = .021$.

The effect size for attitude outcomes was moderate. Eta-squared was .15, representing a medium-to-large effect, while r was .42, indicating a medium effect. Although smaller than the achievement effect, this represents a meaningful impact, suggesting that the SWOM strategy positively influenced students' affective disposition toward CIT learning in addition to cognitive outcomes.

Table 3. Mann-Whitney U Test for Post-Intervention Attitude Scores

Group	*n*	Mean Rank	Sum of Ranks	U	z	*p*	η²	r
Control	15	11.80	177.00	57.00	-2.305	.021	.15	.42
Experimental	15	19.20	288.00					

9.4. Supplementary Analysis: Attitude Subscale Outcomes

Exploratory analysis of attitude subscale scores provided additional insight into the nature of attitude changes. As shown in Table 4, the experimental group demonstrated significantly higher scores on all three subscales: Enjoyment/Interest (U = 52.50, $p = .012$), Perceived Usefulness (U = 59.50, $p = .028$), and Self-Efficacy (U = 61.00, p = .034). The strongest effect emerged for the Enjoyment/Interest dimension (r = .45), suggesting that SWOM instruction notably enhanced students' intrinsic motivation and engagement with CIT content.

Table 4. Mann-Whitney U Tests for Attitude Subscale Scores

Attitude Dimension	Group	*n*	Mean Rank	U	z	*p*	r
Enjoyment/Interest	Control	5	11.50	52.50	-2.512	.012	.45
	Experimental	5	19.50				
Perceived Usefulness	Control	5	12.07	59.50	-2.198	.028	.40
	Experimental	5	18.93				
Self-Efficacy	Control	5	12.20	61.00	-2.120	.034	.39
	Experimental	5	18.80				

10. Discussion.

10.1. Interpretation of Key Findings

This quasi-experimental study yields two principal findings regarding the implementation of the School-Wide Optimum Model in middle school computer education. First, students receiving SWOM-based instruction demonstrated substantially higher academic achievement on standardized content assessments compared to peers receiving traditional instruction. The large effect size ($\eta^2 = .33$, r = .58) indicates this difference is both statistically significant and educationally meaningful. Second, SWOM instruction produced significantly more positive attitudes toward learning computer and information technology, with a moderate effect size ($\eta^2 = .15$, r = .42) that nevertheless represents a practically important shift in student disposition.

The achievement findings align with and extend previous research on SWOM across other disciplines. The magnitude of effect observed in this study (.33) compares favorably with effects reported in chemistry (Al-Lami & Al-Rubaie, 2017), biology (Ibrahim & Hussein, 2019), and jurisprudence (Aujan, 2021), suggesting SWOM's efficacy translates effectively to the technical domain of computer education. Theoretically, these results support the constructivist premise that active cognitive engagement with content—facilitated by structured application of thinking skills—produces deeper, more transferable learning than passive reception of information. In the context of CIT education, where concepts can be abstract and procedural knowledge often dominates, SWOM's emphasis on questioning, comparing, and problem-solving may help students build robust mental models of digital systems and processes.

The positive attitude outcomes are particularly noteworthy given common challenges with student engagement in technical subjects. The significant improvements across all three attitude dimensions—enjoyment, perceived usefulness, and self-efficacy—suggest SWOM addresses multiple aspects of student motivation. By framing CIT learning as collaborative problem-solving rather than individual skill acquisition, SWOM likely enhanced the social and intellectual appeal of the computer class. This aligns with research indicating that metacognitive approaches increase students' sense of ownership and agency in learning (Salman & Alwan, 2020). The strongest effect on enjoyment/interest ($r = .45$) may reflect SWOM's success in making technical content more intellectually stimulating and less monotonous—a common critique of traditional computer instruction noted by Al-Shammari and Al-Massad (2009)

These results are consistent with prior quasi-experimental studies reporting positive effects of SWOM on achievement and related outcomes (Aujan, 2021; Khalifa, 2021; Salman & Alwan, 2020; Ibrahim & Hussein, 2019). Collectively, the evidence suggests that integrating thinking skills with content through SWOM can enhance learning outcomes and promote more positive learning attitudes.

10.2. Theoretical Implications

The results have several implications for theories of learning and instruction in technology education. First, they provide empirical support for the applicability of general metacognitive frameworks to technology skill domains. While metacognitive strategies have often been associated with verbal or conceptual learning, this study demonstrates their utility in a field combining conceptual understanding with procedural knowledge. This extends the theoretical reach of metacognition research and suggests that thinking-skills frameworks like SWOM can help bridge the often-cited gap between conceptual knowledge and practical skills in technology education.

Second, the findings contribute to cognitive load theory as applied to complex learning domains. Computer education often presents high intrinsic cognitive load due to the complexity of systems and procedures. SWOM's structured approach to breaking down problems and explicitly teaching thinking strategies may help manage this load by providing cognitive scaffolding. The progression from questioning to decision-making offers a systematic heuristic for approaching unfamiliar digital tasks, potentially reducing extraneous cognitive load and freeing mental resources for deeper learning.

Third, the attitude findings intersect with self-determination theory, which emphasizes autonomy, competence, and relatedness as key drivers of intrinsic motivation. SWOM appears to support all three: autonomy through student-directed inquiry, competence through mastery of thinking strategies applicable across tasks, and relatedness through collaborative problem-solving. This theoretical alignment helps explain why SWOM enhanced both achievement and attitudes—it addressed fundamental psychological needs that traditional instruction often neglects.

10.3. Practical Implications for Computer Education

The study's findings suggest several actionable implications for CIT pedagogy and curriculum design:

1 .Integrate Metacognitive Strategies Explicitly: Computer curricula should move beyond software proficiency to explicitly teach thinking skills for digital problem-solving. The six SWOM skills provide a practical framework for this integration. Curriculum designers should embed opportunities for questioning, comparing, predicting, and decision-making within existing CIT content.

2 .Redesign Professional Development: Teacher training programs should equip computer educators with metacognitive instructional strategies. Professional development should include modeling of SWOM implementation, opportunities for practice with feedback, and guidance on adapting thinking skill instruction to different technology topics and grade levels.

3 .Reconceptualize Assessment: Assessment in CIT should evaluate not only technical skill execution but also the thinking processes underlying technology use. Performance assessments, portfolios, and reflective prompts can capture dimensions of learning that multiple-choice tests may miss.

4 .Create Supportive Learning Environments: Implementing strategies like SWOM may require physical space reorganization (flexible seating for collaboration), extended time blocks for deep problem-solving, and access to diverse digital tools that support inquiry and experimentation.

5 .Address Attitudinal Dimensions Systematically: Computer education initiatives should intentionally be

designed for positive attitude development; not assume it will follow naturally from technical instruction. Framing technology use as creative problem-solving rather than a routine procedure, connecting skills to meaningful real-world applications, and fostering collaborative learning communities can enhance students' affective engagement.

10.4. Limitations and Directions for Future Research

Several limitations qualify the study's conclusions and suggest productive avenues for further investigation. First, the small sample size (N = 30) limits statistical power and generalizability. While effect sizes were substantial, replication with larger samples across diverse settings is needed to confirm these findings. Second, the use of intact classes rather than random assignment introduces potential selection bias, though pre-test equivalence testing partially addressed this concern. Future studies should employ randomized designs where feasible.

Third, the intervention's relatively short duration (4 weeks) raises questions about long-term impact. Research should examine whether SWOM's benefits persist over time and whether thinking skills transfer to new technology learning contexts. Fourth, the study focused on a specific age group (Ninth grade) and cultural context (Saudi Arabia). Cross-cultural replications and investigations across different grade levels would clarify SWOM's general applicability.

Fifth, the study did not isolate which components of the SWOM model contributed most to observed effects. Future research might employ component analysis designs to determine whether particular thinking skills or their combination drives outcomes. Similarly, measuring intermediate processes (e.g., metacognitive awareness, strategy use) would elucidate mechanisms of change.

Sixth, while the researchers attempted to control for teacher effects by having the same instructor deliver both conditions, potential experimenter bias remains a concern. Future implementations should use multiple instructors who are blind to the research hypotheses. Finally, the study assessed a limited range of outcomes. Additional research should examine SWOM's impact on related constructs such as digital creativity, computational thinking, collaborative skills, and technology self-efficacy *.10.5. Conclusion*

This study provides initial evidence that the School-Wide Optimum Model, a metacognitive instructional strategy, can enhance both academic achievement and learning attitudes in middle school computer education. By systematically integrating six core thinking skills into the CIT curriculum, SWOM appears to foster deeper cognitive engagement with technical content and to make learning experiences more intellectually stimulating and personally meaningful for students. The substantial effect sizes, particularly for achievement outcomes, suggest this approach warrants serious consideration by educators, curriculum developers, and policymakers seeking to improve digital literacy education.

The findings underscore the importance of moving beyond procedural skill transmission in technology education toward approaches that develop students' capacities to think critically and adaptively about digital systems and problems. In an era of rapid technological change, such thinking skills may prove more durable than specific software proficiencies. The SWOM framework offers one practical pathway for cultivating these essential capacities.

For computer educators, the implications are clear: effective technology instruction involves teaching students not only how to use digital tools but how to think about digital challenges. This requires pedagogical shifts toward more student-centered, inquiry-based approaches that explicitly develop metacognitive strategies. For educational systems, supporting such shifts will necessitate investment in teacher professional development, curriculum resources that integrate thinking skills with technical content, and assessment systems that value process as well as product.

While further research is needed to address limitations and explore unanswered questions, this study contributes to a growing body of evidence supporting metacognitive approaches in diverse learning domains. It suggests that the future of effective computer education may lie not in newer technologies or more sophisticated software, but in more powerful ways of thinking about technology—and teaching students to do the same.

10.6. future research directions

Future research should initially replicate the current findings using a larger, multi-school sample and implement more rigorous controls for intact-class assignment, such as class-level randomization when feasible or matched classes based on pretest covariates. Additionally, it is important to explicitly document the fidelity of SWOM implementation as an overlay on the same curriculum. Such a design would evaluate the robustness and broad applicability of the SWOM “added value” beyond a single institution and a limited sample size, while also elucidating how variations in fidelity—pertaining to the quality and frequency of SWOM prompts and routines—are associated with achievement and attitude outcomes.

Secondly, future research should expand outcome measurements beyond immediate unit achievement to investigate mechanisms, durability, and transferability. This can be achieved by incorporating direct indicators of metacognitive regulation during computing tasks, such as planning, monitoring, and evaluation measures, along with brief learning journals or task-based think-aloud protocols. Additionally, delayed post-tests and innovative performance assessments, such as debugging or problem-solving tasks within a new CIT unit, should be used. This approach will help determine whether SWOM yields sustained, transferable improvements in middle-school computing education and whether these gains are attributable to enhanced metacognitive strategy use.

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