Daily Quizzes for Computing Competency: Strengthening Fundamentals and Workforce Readiness in Senior Capstone

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Abstract

Senior capstone courses are built to be the culminating experience in a computing degree, yet their project-focused structure rarely asks students to look back across the curriculum they are about to leave behind. This study examines a simple response to that gap: short, low-stakes daily quizzes integrated into a senior computing capstone course, prompting retrieval of foundational concepts spanning algorithms, data structures, operating systems, software engineering, and professional practice, running alongside project work rather than replacing it.

Drawing on qualitative content analysis of 148 coded student responses across multiple semesters, and grounded in Retrieval Practice Theory, Formative Assessment Theory, and Cognitive Load Theory, this study finds that students experienced the quizzes as surfacing forgotten material, normalizing shared knowledge gaps among peers, and building the confidence and articulation needed for professional practice. Students also identified clear design conditions under which the intervention worked best, including immediate feedback and content transparency. Rather than measuring causal learning gains, this study contributes practice-based evidence illustrating how retrieval-based formative assessment can complement project-based learning in advanced computing courses. The findings offer actionable guidance for educators seeking to strengthen disciplinary coherence and workforce readiness, and raise timely questions about retrieval fluency in an era where generative AI can surface facts on demand but cannot substitute for the judgment to evaluate them.

Introduction

What should a graduating computer science student still know, and how would they know if they had forgotten? This question sits quietly beneath one of the more persistent tensions in computing education: the senior capstone course is designed to be a culminating experience, yet its structure rarely asks students to demonstrate that their earlier learning has survived.

Capstone courses emphasize open-ended, team-based projects that require students to integrate technical knowledge, professional skills, and design judgment while working on authentic problems. As such, capstone courses are often intentionally light on lectures and traditional assessments, prioritizing autonomy, creativity, and experiential learning [1, 2]. The tradeoff is real, however. As students focus on the specific technologies and domains relevant to their projects, they may spend an entire semester without revisiting foundational computing concepts from earlier coursework [3]. Students frequently report uncertainty about whether they still command what they are supposed to know as they approach graduation, a concern that becomes acute during technical interviews, final presentations, and the transition into professional roles where recall and articulation of core concepts are routinely expected [4].

In computing disciplines, this challenge is amplified by the cumulative nature of the curriculum. Core topics such as algorithms, data structures, operating systems, software engineering

principles, and systems thinking are typically introduced early and revisited unevenly in later coursework. While mastery of specialized topics is essential, graduates are also expected to retain and integrate foundational knowledge across subdisciplines. Capstone courses, despite their summative intent, rarely include explicit mechanisms for reinforcing this cumulative understanding.

One instructional strategy with strong empirical support in learning science is retrieval practice through frequent, low-stakes formative assessment. Decades of research demonstrate that retrieval practice is more effective for long-term retention than passive review or repeated exposure [5]. Yet, despite its demonstrated benefits, retrieval-based assessment is rarely employed in senior capstone courses, particularly in computing, where assessment is often limited to project deliverables and presentations [6, 7].

To address this gap, we integrated short, daily quizzes into a senior computer science and computer engineering capstone course. Unlike traditional quizzes tied to lecture content, these assessments drew from core concepts spanning the undergraduate computing curriculum as well as professional practices relevant to capstone work. The intent was not to reintroduce exams or increase grading pressure, but to provide a lightweight, consistent mechanism for reinforcing disciplinary expectations, identifying knowledge gaps, and supporting student confidence during a critical transition period.

This paper examines how students experienced daily low-stakes quizzes within a capstone context. Drawing on data from three course sections across multiple semesters—individual student meeting notes and representative quiz artifacts—we explore student perceptions of how retrieval-based assessment influenced their learning, confidence, and readiness for professional practice. Rather than evaluating quizzes as assessment instruments or measuring causal learning gains, this study focuses on student voice and instructional design, offering practice-based evidence relevant to computing educators seeking to balance experiential learning with reinforcement of foundational knowledge.

Theoretical Framework and Related Studies

Three complementary frameworks inform how daily quizzes function within a capstone course, each addressing a distinct dimension of student experience.

Retrieval Practice Theory holds that actively recalling information from memory produces stronger long-term retention than restudying the same material [5, 6]. The mechanism, sometimes called the testing effect, is not simply a matter of repetition; the act of retrieval itself strengthens memory traces and surfaces gaps that passive review tends to obscure [8]. In this study, daily quizzes operationalize retrieval practice by prompting students to recall foundational computing concepts at regular intervals, independent of and running in parallel to their project work.

Formative Assessment Theory, as developed by Black and Wiliam [7], frames assessment not as a measurement endpoint but as an ongoing instructional process. Effective formative assessment provides timely feedback, clarifies disciplinary expectations, and gives students the means to adjust their understanding before summative judgment. The quiz design examined here reflects these principles: low stakes, frequent administration, and an emphasis on surfacing gaps rather than assigning grades. Importantly, student data from this study also reveal where the formative

loop remained incomplete, particularly in cases where answers were unavailable or the source of quiz content was unclear. This finding extends and complicates straightforward applications of formative assessment in capstone contexts, and is taken up in the results and discussion.

Cognitive Load Theory [9, 10] distinguishes between extraneous load, the mental effort imposed by unclear or poorly designed instruction, and germane load, the effort directed toward actual learning. Senior capstone students approaching graduation carry considerable extraneous load: uncertainty about what they are expected to know, anxiety about technical interviews, and awareness of a four-year curriculum receding in working memory. The low-stakes, brief, and consistent design of the daily quizzes addresses this burden by making disciplinary expectations visible and recurring. Students in this study repeatedly described the quizzes not as stressful additions but as clarifying anchors, a perception consistent with CLT's account of how well-designed instructional supports free cognitive resources for genuine engagement.

Together, these three frameworks map onto the three phases of the quiz interaction illustrated in Figure 1: retrieval practice theory governs the act of individual recall, formative assessment theory shapes the feedback and peer discussion phase, and cognitive load theory explains the cumulative confidence and readiness students report across the semester.

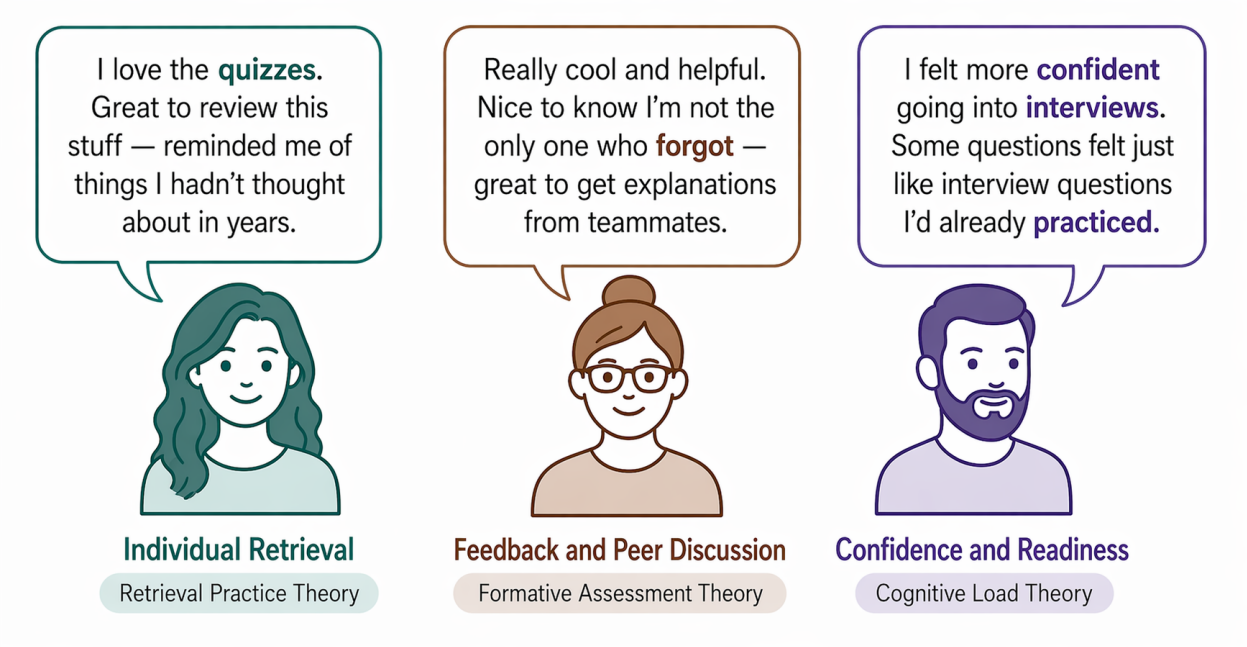

FIGURE 1. Three phases of daily quiz interaction and their anchoring theoretical frameworks. Each phase reflects a distinct dimension of student experience observed across multiple semesters: individual retrieval of foundational computing knowledge (Retrieval Practice Theory), formative feedback that clarifies disciplinary expectations and surfaces knowledge gaps (Formative Assessment Theory), and the cumulative reduction in cognitive load that supports confidence and professional readiness (Cognitive Load Theory). Student quotes are paraphrased from individual meeting notes to preserve anonymity.

Retrieval Practice and Formative Assessment

A substantial body of research demonstrates that frequent retrieval of information from memory enhances long-term retention more effectively than passive review or restudying. Early experimental work on the testing effect established that students who engage in retrieval practice retain material at significantly higher rates than those who restudy it, even when retrieval is low-stakes and ungraded [5]. Subsequent studies have replicated and extended these findings across educational levels and disciplinary contexts, establishing retrieval practice as one of the most robust strategies in the learning sciences [6, 11].

Formative assessment supports learning through a related but distinct mechanism: it provides feedback during the learning process rather than after it, revealing gaps in understanding while there is still time to address them [7]. The effectiveness of formative assessment depends heavily on its design. Assessments that are frequent, low-stakes, and clearly tied to learning expectations promote engagement and self-regulation; those that are high-stakes or infrequent tend to generate anxiety without proportional learning benefit [12]. Both bodies of work directly inform the design choices examined in this study.

Assessment in Project-Based and Capstone Courses

Engineering and computing capstone courses are typically structured around open-ended problem solving, team-based design, and authentic project constraints [1, 2]. Assessment in these environments reflects that structure: evaluation centers on final artifacts, presentations, and demonstrations of professional skill, with little emphasis on structured assessment of cumulative technical knowledge. Prior work has documented the predictable consequence: students in project-based environments focus narrowly on technologies relevant to their specific projects while broader disciplinary concepts recede from active use [3].

Research on capstone assessment has also highlighted the difficulty of evaluating individual learning within team contexts, and the tension between creative freedom and standardized expectations [13, 14]. What the literature has not examined in depth is how formative assessment might be introduced into capstone courses not to evaluate project work but to run alongside it, reinforcing foundational knowledge without displacing the experiential goals that make capstone education valuable.

Computing Education and Workforce Readiness

The gap between what computing programs teach and what industry expects has been a recurring concern in the field. Employers consistently report that recent graduates struggle to recall and articulate foundational concepts during interviews and early career tasks, even when those graduates performed well academically [4]. This gap is not simply a matter of individual preparation; it reflects a curriculum design problem in which foundational knowledge is introduced early and reinforced unevenly, with no explicit mechanism ensuring its survival through graduation [15].

Technical interviews in computing are a particularly revealing pressure point. They rely on rapid retrieval of fundamental concepts under time constraints, rewarding not just knowledge but the ability to articulate it fluently on demand. The alignment between that format and the daily quiz

structure examined here is not incidental. Whether retrieval-based practice embedded within a capstone course shapes students' perceived readiness for these evaluations is one of the questions this study addresses, though through student perception rather than verified interview outcomes.

Methods and Data Sources

Course Context

This study was conducted in a senior-level capstone course for undergraduate computer science and computer engineering majors at a large public research university. The course spans a full semester and centers on team-based, industry-sponsored or research-driven projects. As is typical for capstone courses, formal lectures are minimal, and assessment traditionally focuses on project milestones, final deliverables, and presentations [1, 2].

To reinforce cumulative disciplinary knowledge and support student readiness for graduation and professional practice, the instructional team integrated short, low-stakes daily quizzes throughout the semester. These quizzes were designed to prompt retrieval of core computing concepts from across the undergraduate curriculum, including algorithms, data structures, operating systems, software engineering, security, machine learning fundamentals, and professional practice.

Daily Quiz Design

Each quiz consisted of approximately 8-15 multiple-choice or short-answer questions and was administered electronically. Quiz questions emphasized conceptual understanding rather than memorization and were intentionally aligned with knowledge expected of graduating computer science and computer engineering students. In addition to technical content, some quizzes included questions related to professional communication, ethical practice, design principles, and capstone expectations.

The quizzes were formative in nature: they were low-stakes, frequent, and intended to help students identify gaps in their understanding rather than to function as summative assessments. Five quizzes were selected at random from the semester and are included as representative artifacts to illustrate the breadth and consistency of content covered (see Table 2 in Appendix A). Quizzes were typically completed in under 10 minutes, reinforcing their role as lightweight instructional supports rather than primary assessments.

Student Meeting Data

The primary data source for this study consists of individual, semi-structured student meetings conducted as part of the capstone course over multiple semesters. Each student participated in at least one one-on-one meeting with the instructor during the semester. These meetings focused on student progress, challenges, reflections on learning, preparedness for graduation, and perceptions of course structure and instructional practices. All sections followed the same course structure and assessment practices.

Detailed notes were recorded during or immediately following each meeting. Across multiple semesters, students independently and repeatedly commented on the daily quizzes, often without direct prompting. These comments included reflections on perceived learning benefits, confidence

in recalling foundational material, interview preparedness, and the role of quizzes in maintaining engagement with core computing knowledge during an otherwise project-focused course.

Qualitative Analysis

Qualitative content analysis with systematic open coding was conducted independently by two researchers with no instructional role in the course examined [16]. Initial codes were generated from the full dataset of 148 student responses, then reviewed and consolidated into themes through discussion between coders. Themes were retained when supported by consistent patterns across multiple semesters and cohorts.

This analysis emphasizes student perceptions and experiences rather than causal claims about learning outcomes. The goal was to understand how students experienced retrieval-based formative assessment within a senior capstone context and how they interpreted its role in supporting disciplinary readiness and professional preparation.

Scope and Limitations

This study does not attempt to establish causal relationships between quiz participation and objective learning gains or employment outcomes. The findings are grounded in longitudinal student reflections and instructional artifacts collected within a specific institutional and disciplinary context. One limitation worth naming directly is that meeting notes, while detailed, are instructor-recorded summaries rather than verbatim transcripts, which introduces selection in what was captured. A second limitation is that the dataset includes students whose foundational knowledge varied in ways that reflect curriculum inconsistencies across cohorts, including knowledge gaps attributable to disrupted instruction during the COVID-19 pandemic, rather than individual preparation alone. These contextual factors are acknowledged where relevant in the results. The underlying instructional approach and design principles are nonetheless transferable to other computing-focused capstone and project-based courses. This study was reviewed and determined to be exempt by the Texas A&M University Institutional Review Board (IRB ID: STUDY2026-0091).

Results

Qualitative content analysis of 148 coded student responses across three course sections and multiple semesters yielded six recurring themes related to the use of daily quizzes in the senior capstone course. These themes emerged predominantly without direct prompting during individual student meetings, lending weight to their salience in the overall student experience. Figure 2 shows the distribution of themes across the coded dataset. The analysis is organized into five subsections; the final subsection addresses two closely related themes concerning feedback transparency and perceived content arbitrariness together, as both reflect student-identified constraints on the intervention's effectiveness rather than outcomes of it.

Foundational Knowledge Reinforcement

The most prominent theme, present in 49% of coded responses, centered on students' experience of the quizzes as a mechanism for recalling foundational computing knowledge that had not been

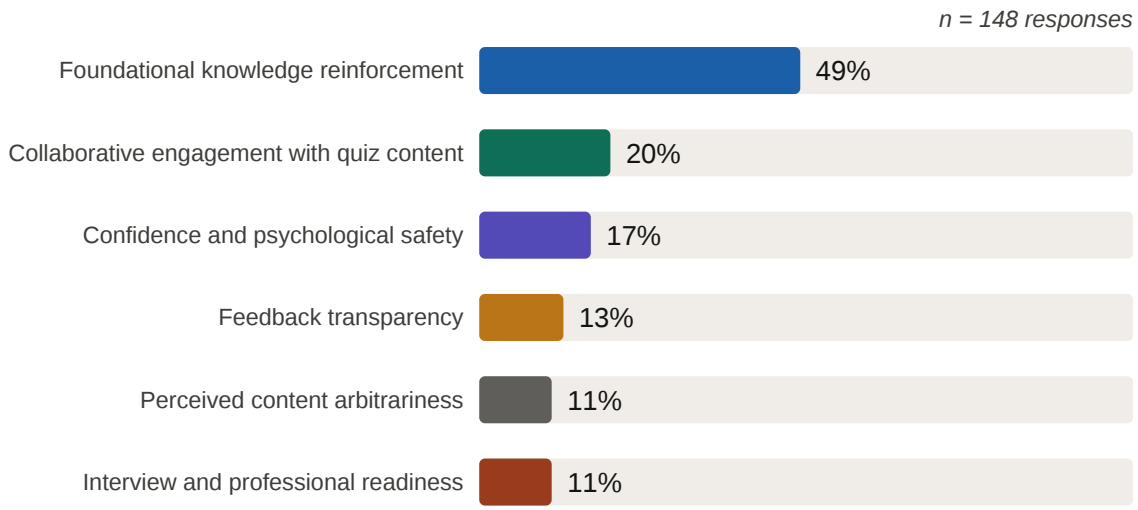

FIGURE 2. Distribution of themes across 148 coded student responses. Responses could reflect multiple themes; therefore, percentages do not sum to 100%.

actively engaged since earlier in their academic careers. Students consistently described the quizzes as surfacing forgotten material spanning algorithms, data structures, operating systems, security, and software engineering principles. The regularity of this pattern across cohorts and semesters suggests it reflects a structural feature of the capstone experience rather than individual variation in preparation.

Students did not describe this retrieval as stressful. The dominant framing was one of productive rediscovery: the quizzes reminded students what they already knew, even when that knowledge had grown dormant. One student described the experience as *"a good wrap-up of everything from the last four years,"* while another noted that the quizzes *"helped me remember things I hadn't thought about in years."* Several students reflected on realizing gaps in their understanding that they had assumed were resolved, framing these moments not as failures but as actionable signals for targeted review before graduation.

A notable subset of responses identified specific knowledge gaps traced to pandemic-disrupted instruction. Students in later cohorts named topics such as hash functions, ACID database principles, and IRB procedures as content they could not recall because it had been taught during remote learning periods. This finding complicates a straightforward retrieval practice account: the quizzes were occasionally asking students to retrieve knowledge they may never have reliably encoded. The distinction between forgotten knowledge and never-consolidated knowledge has implications for how retrieval-based practice is designed and interpreted in curricula that experienced disruption.

Collaborative Engagement with Quiz Content

Twenty percent of coded responses referenced the social dimension of engaging with quiz content alongside teammates. This theme reflects two related but distinct patterns in the data. In sections where a structured two-attempt format was in place, students explicitly valued the

TABLE 1. Summary of Qualitative Coding Themes and Representative Student Perceptions

Theme	Description	Representative student perception
Foundational knowledge reinforcement	Quizzes prompted active recall of computing concepts from earlier coursework, surfacing forgotten material across algorithms, systems, and software engineering.	*"Helped me remember things I hadn't thought about in years — a good wrap-up of everything from the last four years."*
Collaborative engagement with quiz content	Students valued working through quiz content with teammates, normalizing shared knowledge gaps through discussion and peer explanation.	*"I like the individual to group. Nice to know I'm not the only one who doesn't remember."*
Confidence and psychological safety	Repeated low-stakes exposure reduced anxiety about disciplinary preparedness and clarified expectations before graduation.	*"Low stakes meant I could be wrong — that's actually when I learned."*
Interview and professional readiness	Students linked quiz content to technical interview preparation, though perceptions were mixed across hiring contexts.	*"Some questions felt just like interview questions I'd already practiced."*
Feedback transparency	Students preferred immediate access to correct answers, identifying delayed feedback as a barrier to consolidating learning.	*"If I get it wrong, I don't go back and look — I need to see the answers right away."*
Perceived content arbitrariness	Some students experienced quiz topics as disconnected from recognizable coursework, particularly where content traced to pandemic-disrupted instruction.	*"I don't know where the information is coming from — some of it I may never have learned."*

Note: Quotes are paraphrased from individual meeting notes to preserve anonymity and represent recurring sentiments across cohorts.

individual-to-group progression, describing the team discussion phase as an opportunity to reconstruct shared understanding of concepts none of them had fully retained. In sections where no formal group format existed, students spontaneously described discussing quiz content with teammates after the fact, or advocated for such a format as a design improvement.

Across both patterns, a consistent affective note emerged: the discovery that peers shared the same knowledge gaps was itself experienced as reassuring and motivating. One student put it plainly: *"I like the individual to group. Nice to know I'm not the only one who doesn't remember."* Another described the experience as *"really cool and helpful — it was nice to talk to team members and get explanations."* The social normalization of not-knowing, which individual retrieval practice cannot produce on its own, appears to be a meaningful affordance of the capstone context specifically, where students work in teams and share a common disciplinary background.

Students who did not have access to a structured group format were notably consistent in requesting one, suggesting that the collaborative dimension was perceived as a natural extension of the quiz's purpose rather than an add-on. This pattern has practical implications for quiz design

in team-based courses and is taken up in the discussion.

Confidence and Psychological Safety

Appearing in 17% of coded responses, this theme concerns the affective dimension of repeated low-stakes exposure. Students described the quizzes as reducing the ambient uncertainty that accompanies the final semester of a computing degree, when the breadth of four years of coursework can feel simultaneously overwhelming and inaccessible. The low-stakes design was central to this effect. Students who might have found the same content threatening in a high-stakes format described approaching the quizzes with equanimity, and in some cases genuine enthusiasm.

Several students drew an explicit contrast with other project-based experiences, where weeks passed without any structured engagement with foundational concepts. In those contexts, students described growing uncertainty about whether they were adequately prepared. The daily quizzes served as a repeated reference point, making disciplinary expectations visible and reducing what might be understood, in terms of Cognitive Load Theory, as extraneous load: the mental burden of not knowing what one is supposed to know. One student captured this directly: *"low stakes meant I could be wrong — that's actually when I learned."* Another noted: *"I felt more confident going into interviews."*

It is worth acknowledging that a minority of students experienced the quizzes as frustrating rather than reassuring, particularly when surfaced gaps were not followed by clear feedback or remediation pathways. For these students, the design amplified rather than reduced uncertainty. This tension is addressed directly in the design tensions subsection below.

Interview and Professional Readiness

Eleven percent of coded responses connected quiz content to preparation for technical interviews and early professional practice. Students described recognizing quiz questions in interview settings, crediting the quizzes with helping them articulate foundational concepts under time pressure. *"Some questions felt just like interview questions I'd already practiced"* was a sentiment that recurred across cohorts, and several students described the quizzes as helping identify *"what to study for interviews or general knowledge to re-learn."*

These perceptions were not uniform. A meaningful subset of students questioned the alignment between quiz content and contemporary hiring practices, noting that many of their actual interviews had been behavioral rather than technical, and that industry was moving away from rapid-fire foundational questioning. One student observed that companies were *"moving away from Leetcode-style questions,"* and that two of their interviews *"were behavioral, not technical."* Another acknowledged the quizzes as a useful refresher while noting that they had not been asked questions of that type in any of their actual interviews.

This heterogeneity is itself a finding worth reporting honestly. Whether daily retrieval quizzes prepare students for technical interviews depends on the hiring context of the roles they pursue, which varies considerably across the computing industry. The paper does not claim that quizzes produce interview success; it reports that students perceived a connection, with the important qualification that this perception was not universal and that the landscape of technical

interviewing continues to shift.

Design Tensions: Feedback Transparency and Perceived Content Arbitrariness

Two themes in the dataset are best understood not as outcomes of the quiz intervention but as student-identified constraints on its effectiveness. Together they appeared in approximately 24% of coded responses and point to specific design features that, when absent or poorly handled, limited the learning value students were able to extract.

The first concerns feedback transparency, present in 13% of responses. Students expressed a clear and consistent preference for immediate access to correct answers following quiz submission. Those who did not receive timely feedback described a predictable consequence: they moved on without consolidating what they had gotten wrong. *"If I get it wrong, I don't go back and look — I need to see the answers right away"* captured a sentiment that appeared across multiple cohorts. In sections or semesters where answers were released promptly, students described a meaningfully different experience. This is consistent with Formative Assessment Theory's emphasis on feedback proximity: the closer feedback follows retrieval, the more likely it is to strengthen rather than merely reveal a gap [7, 12]. Feedback timing is a modifiable design variable, and its effect on student engagement was visible in the data.

The second tension concerns perceived content arbitrariness, present in 11% of responses. Students described quiz topics as feeling random, disconnected from identifiable coursework, or drawn from material they did not recognize as part of their education. Requests for a topic preview or list of source courses were common, and *"I don't know where the information is coming from"* recurred across cohorts. Some of this perception reflects genuine curriculum gaps from pandemic-disrupted instruction rather than quiz design choices alone. One student described a quiz question on ACID database principles where *"nobody in the group knew the answer — only one person knew it from an internship, not from the class."* That experience sits at the boundary between retrieval practice and new learning, and it points to the importance of calibrating quiz content to what a cohort can reasonably be expected to have encountered.

Taken together, these two tensions do not undermine the positive findings reported in earlier subsections. They refine them. The quizzes worked best when feedback was immediate and content was legible to students as part of their own educational history. Where those conditions were not met, student engagement narrowed and the intervention's benefit contracted. Both are tractable design problems, and both are addressed in the discussion that follows.

Discussion

The findings of this study extend prior work on retrieval practice and formative assessment by situating both within a context where neither is typically employed: the senior computing capstone. Students approaching graduation in a project-focused course are not a natural audience for daily quizzes. That they perceived those quizzes as meaningful, confidence-building, and relevant to their professional futures is itself a finding worth examining carefully.

Theoretical Interpretations

Each of the three frameworks anchoring this study finds grounding in the results, and in one case finds a complication that the literature has not fully addressed.

Retrieval Practice Theory predicts that the act of recalling information from memory strengthens long-term retention more effectively than restudying [5, 8]. The foundational knowledge theme, present in nearly half of all coded responses, is consistent with this prediction. Students described the quizzes as surfacing concepts that had receded from active memory during months of specialized project work, and they did so unprompted, across cohorts, and across semesters. The pattern is robust. What the data also reveal, however, is a boundary condition that the retrieval practice literature has not foregrounded: retrieval requires prior encoding. Students who encountered quiz questions on material taught during pandemic-disrupted semesters were not retrieving forgotten knowledge; they were encountering content they had never reliably learned. This distinction matters for practitioners designing retrieval-based interventions in curricula that have experienced disruption, and it points to the value of calibrating quiz content against the actual learning history of a given cohort rather than against an idealized curriculum map.

Formative Assessment Theory frames effective assessment as an ongoing process that clarifies expectations, surfaces gaps, and enables adjustment [7]. The confidence and psychological safety theme reflects this mechanism: students who encountered foundational concepts regularly reported reduced uncertainty about what they were expected to know, which is precisely the expectation-clarifying function that Black and Wiliam describe. The feedback transparency theme, however, reveals where the formative loop broke down in practice. When answers were not released promptly, students disengaged rather than reflecting. Nicol and Macfarlane-Dick's principle that effective feedback must be timely and actionable [12] was not uniformly met in this implementation, and the data show the consequence clearly. Formative assessment is not a property of the assessment instrument alone; it is a property of the full feedback cycle, and that cycle was incomplete in sections where answer transparency was delayed.

Cognitive Load Theory distinguishes between extraneous load, imposed by poor design, and germane load, directed toward learning [9, 10]. The low-stakes design of the daily quizzes appears to have reduced extraneous load in a specific and important way: it removed the cost of not-knowing. In a high-stakes assessment, a gap in foundational knowledge is a liability. In a low-stakes daily quiz, it is simply information. Students described this shift explicitly, framing the quizzes as clarifying rather than threatening. The collaborative engagement theme adds a social dimension to this account: when students discovered that their teammates shared the same gaps, the extraneous load of uncertainty was further reduced. Peer normalization of not-knowing is a mechanism that individual retrieval practice cannot produce, and it is one that emerges naturally from embedding the practice in a team-based course.

Novel Contributions

Two findings in this study go beyond confirming established frameworks and point to directions the literature has not yet addressed.

The first is the collaborative normalization effect. Students across cohorts described the discovery that peers shared their knowledge gaps as reassuring and motivating. This is not simply a social

learning phenomenon; it is a capstone-specific affordance. Capstone students work in teams, share a common disciplinary history, and are simultaneously preparing for professional practice. The conditions that make collaborative quiz engagement natural in this context do not exist in most introductory or intermediate courses where retrieval practice research has been conducted. Future work should examine whether structuring retrieval practice around team-based formats, rather than treating it as an exclusively individual cognitive act, amplifies its effect in collaborative learning environments.

The second is the curriculum gap finding. The consistent appearance of pandemic-era knowledge deficits in student responses, named specifically and across multiple cohorts, suggests that COVID-disrupted instruction left identifiable traces in what graduating students could and could not retrieve. Programs that have not audited which foundational topics were taught under remote conditions may be graduating students with invisible gaps that neither the students nor their instructors are fully aware of. A retrieval-based intervention like daily quizzes can serve as a diagnostic tool for surfacing these gaps at scale, a function distinct from and complementary to its learning function.

Design Implications for Computing Educators

Three design decisions emerge from this study as particularly consequential for practitioners who wish to adopt a similar approach.

Feedback must be immediate. The evidence on this point is unambiguous in both the formative assessment literature and in this dataset. Releasing answers after each quiz session costs little and changes the learning experience substantially. Instructors who treat the quiz as a grade-generating instrument rather than a feedback mechanism will find the benefits narrowed.

Content should be legible to students as part of their own education. The perceived content arbitrariness theme points to a solvable transparency problem. Providing students with a list of source topics or curriculum areas, or maintaining a running list of quiz domains across the semester, would likely reduce the sense of randomness without reducing the retrieval benefit. Students do not need to know the specific questions in advance; they need to know the territory.

The collaborative format is worth formalizing. Where a structured individual-to-group format was in place, students described it consistently as one of the most valuable features of the quiz experience. The social normalization it produced, and the peer explanation it enabled, extended the learning value beyond what individual retrieval alone could achieve. Instructors who have not yet formalized a team discussion phase are leaving that value on the table. The quiz design examined here has been in iterative use for approximately a decade and has been independently adopted by multiple instructors within the same program, evidence that the approach is practical and adaptable without substantial restructuring of existing capstone courses.

Retrieval Practice in the Age of Generative AI

Any forward-looking discussion of retrieval-based assessment in computing education must contend with a shift that was already underway in the later cohorts of this study: the widespread availability of generative AI tools. Several student responses alluded to the option of searching online or consulting external resources during quizzes, and the broader cultural context of

AI-assisted work was present in how students thought about the relevance of foundational knowledge. This raises a question that the field is only beginning to examine seriously: if a language model can produce a definition of the CIA triad or explain round-robin scheduling on demand, what is the value of being able to retrieve that knowledge independently?

The answer, we argue, is not diminished by the existence of generative AI, but in some respects sharpened by it. A practitioner who cannot retrieve foundational knowledge independently cannot effectively evaluate, correct, or supervise an AI system that produces it. Recognizing when a generated answer is subtly wrong, knowing which edge cases a model is likely to miss, and understanding why a proposed solution violates a security principle rather than simply accepting that it does: all of these depend on the kind of fluent, retrievable knowledge that daily quizzes cultivate. The professional value of foundational knowledge is shifting from recall on demand to the capacity for informed judgment over AI-generated output, and that capacity requires the same cognitive substrate.

This reframing also speaks directly to the interview readiness theme. Students who questioned whether technical interview preparation remained relevant were responding to a real shift in hiring practice. But the shift is not toward irrelevance of foundational knowledge; it is toward a different demonstration of it. Increasingly, technical interviews assess whether candidates can reason about AI-generated code, identify its limitations, and extend it appropriately. The retrieval fluency that daily quizzes develop is not obsolete in this landscape; it is precisely what distinguishes a thoughtful practitioner from a prompt engineer.

Limitations and Future Work

This study contributes practice-based evidence rather than causal claims. The findings reflect student perceptions collected within a specific institutional and disciplinary context, and the analysis rests on instructor-recorded meeting notes rather than verbatim transcripts, which introduces selection in what was captured. Two independent coders reviewed theme assignments to reduce interpretive bias, but the primary analyst was a researcher familiar with the course context, a limitation acknowledged in the interpretation of findings.

The mixed perceptions around interview readiness point to a limitation in the intervention's scope. Whether daily retrieval quizzes serve professional preparation depends on the industry context students are entering, and that context is not static. As hiring practices continue to shift alongside the growth of generative AI in professional workflows, the alignment between quiz content and professional expectations warrants periodic reassessment.

Future work should pursue several directions. Longitudinal studies that follow students into early career roles would allow the perceived benefits reported here to be tested against observable outcomes. Comparative studies across institutions and disciplines would establish how much of what was found here is specific to computing capstone culture and how much transfers broadly. Studies that examine retrieval practice specifically in the context of AI tool use, including whether foundational knowledge fluency affects the quality of AI-assisted work, represent a particularly timely and underexplored direction. Most importantly, experimental designs that vary specific features of the quiz implementation, including feedback timing, content transparency, and team-based formats, would allow causal claims that this study cannot make. The patterns identified here are consistent and coherent; they deserve the rigor that a controlled investigation

would bring.

Conclusion

There is a quiet irony at the heart of senior capstone education. Students spend a semester demonstrating what they can do with their knowledge, while the question of what they actually still know quietly goes unexamined. Capstone courses are designed to be culminating, but their structure rarely asks students to look back across the curriculum they are about to leave behind.

This study began from a simple premise: that brief, low-stakes daily quizzes could fill that gap without disrupting what makes capstone education valuable. The evidence gathered across multiple semesters and cohorts supports that premise, and reveals something richer. Students did not simply remember things they had forgotten. They gained a clearer picture of what a graduating computer scientist is supposed to know. They found reassurance in discovering that their peers shared the same gaps. They connected the practice to confidence in interviews and articulation under pressure. And they identified, with notable precision, the design features that limited the intervention's effectiveness when those features were absent.

The contribution of this study is not a new theory of learning but a grounded account of a specific, practical, and underutilized instructional approach. Retrieval practice works. Formative assessment works. Cognitive load matters. These are not new claims. What is new is the demonstration that all three can operate together in a context where none of them is typically found, with effects that students notice, name, and carry into professional life.

That demonstration matters more now than it did when these quizzes were first introduced. As generative AI reshapes what it means to know something in a professional context, the temptation to treat foundational knowledge as retrievable on demand from a model rather than from memory will only grow. The students in this study who could articulate why something worked, not just that it worked, were better positioned for that world. Daily quizzes are a small intervention. The capacity they build is not.

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Appendix A: Daily Quiz Artifacts and Qualitative Coding Summary

TABLE 2. Representative Daily Quiz Topics and Learning Domains

Quiz ID	Primary content areas	Example topics covered	Learning purpose
Quiz #5	Software design, development processes, human-centered design	Agile principles, design constraints, error prevention	Reinforce applied software engineering concepts and design reasoning
Quiz #13	Algorithms, complexity, operating systems, ethics, technical communication	NP vs. P, sorting lower bounds, round-robin scheduling, recursion, professional writing conventions	Reinforce foundational CS theory and professional standards
Quiz #14	Capstone expectations, teamwork, design thinking, data structures	Project goals, accountability, conflict, human behavior, hash tables	Clarify capstone norms and reinforce core CS structures
Quiz #18	Evaluation methods, databases, algorithms, technical communication	User studies, qualitative vs. quantitative data, NoSQL vs. SQL, binary search	Reinforce evaluation literacy and data reasoning
Quiz #21	Algorithms, machine learning, security, operating systems	Dijkstra's algorithm, overfitting, CIA triad, OS responsibilities	Reinforce breadth of computing fundamentals expected of graduates

Note: Quizzes were selected at random to illustrate the breadth and consistency of content across the semester.