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Research Article

An Innovative Teaching and Learning Paradigm to Enhance College Students' Long-Term Memory and Learning Gains

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ABSTRACT

This article elaborates on the active ingredients and theory of change used to explain an innovative model of teaching and learning called MISSAL. MISSAL is an abbreviation for Meaningful Instruction, Social, Self-Regulated, and Active Learning. This learning intervention is in the third year of research and development. Drawing upon prior scholarly investigations on brain-based learning and various instructional strategies, the active ingredients of this framework are summarized. Using a sample of 12 undergraduate social work students, and examined to what extent the MISSAL approach facilitates short and long-term knowledge retention and recall of acquired learning, successful exam performance, and learning gains among students enrolled in a content-intensive course. Findings of this preliminary investigation are hopeful. Implications for the higher education sector and future research are discussed.

Keywords: Active learning; Scholarship of teaching and learning; Brain-based learning; Student learning outcomes

INTRODUCTION

The United States Department of Education is mandating greater accountability from the higher education sector. Colleges and universities are encouraged to develop a new paradigm for providing students with rigorous learning experiences and collecting evidence of their learning. This author has used a program development and intervention research model to develop and evaluate a complex paradigm of teaching and learning based on brain-based theory and neuroscience knowledge of how adult students learn since 2020. MISSAL (Meaningful Instruction, Self-Regulated, Social, and Active Learning) is the name of this learning intervention. MISSAL is in the third year of research and development. Based on preliminary findings this methodology has the potential to address student success and escalating problems with persistence, retention, engagement, and motivation to learn. This paradigm is driven by the desire to enhance higher education so that all students can and will learn through full participation, support, and rigorous learning experiences.

MISSAL: Operational framework

MISSAL is a multifaceted educational intervention that encompasses a theoretical framework, instructional materials, educational activities, procedures, and processes that are hypothesized to have an impact on student learning outcomes. The absence of thoughtful contemplation or a detailed description of the active ingredients impedes complete understanding of what makes this intervention effective or ineffective in relation to student achievement. This also prevents other researchers and educators from replicating the practice and study of MISSAL or expanding upon it.

The foundation of this paradigm is constructed upon existing academic literature related to the Scholarship of Teaching and Learning (SoTL), as well as the knowledge gained from neuroscience on the cognitive processes and brain development associated with learning. SoTL has the potential to strengthen the higher education system and fulfill the national "completion agenda" in a variety of ways [1]. Most importantly, when instructional practices are founded on theory and research, it can enhance learning by employing more effective instructional methods [2-5]. Given that education is intended to be an evidence-based practice, it should be based on theory and/or research informed practice. The active ingredients of this framework, which comprise three instructional focus areas and 11 subcategories can be summarized as follows: (Table 1).

Emphasis on outcomes: Outcome-based education is an andragogical approach that focuses on the achievement of certain learning objectives. Advocates of outcome-based professional education argue that methods of instruction should prioritize the acquisition of skills that are considered vital by the community to foster the development of competent professionals among students [6,7].

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Student learning outcomes: A clearly articulated understanding of what students are expected to know and be able to do when they complete an academic program or by the end of a unit of study is crucial to students' academic growth and success. The phrase "outcome-based education" was introduced by Benjamin Bloom to describe an instructional method that he initially formulated during the 1960s. Bloom's "Mastery Learning" approach involves the segmentation of curriculum content into discrete and manageable parts, with students' advancement and readiness for graduation assessed based on their mastery of individual units of learning. According to Bloom, the most effective way to facilitate the development of mastery and higher-order skills is to include high-order tasks as learning objectives, provide practice in class and additional practice on assignments, and then assess students' ability to transfer knowledge to a variety of new contexts. According to Bloom's mastery learning paradigm, it is necessary for students to attain a degree of mastery, such as scoring 90% on a knowledge test, in prerequisite/introductory content prior to progressing towards acquiring advanced knowledge.

The assessment process begins with the formulation of appropriate student learning outcomes. Bloom's Taxonomy of Learning can be used to categorize educational learning objectives in accordance with the specificity and complexity of the target student learning outcomes. Target learning outcomes should be succinct, easy to measure and analyze, and clearly communicated to students. In the MISSAL approach, student learning outcomes play a pivotal role in the development or revision of lesson plans, the selection of educational resources, the implementation of instructional approaches, and the evaluation of student learning.

Every module in the MISSAL methodology consists of two phases of learning. Each module's initial phase of learning begins with students being apprised of the module's particular goals for learning. Outcomes are written in student-friendly language and describe what students will be able to do by the end of the course, in addition to the criteria for success. Typically, outcomes and assessment tasks pertain to authentic professional responsibilities. Bloom's Taxonomy of Learning is used to categorize educational learning objectives according to the specificity and complexity of the intended student learning outcomes. Students are apprised of the learning objective *via* the course outline, the LMS system, and the instructor of record throughout the duration of the lesson.

Constructive alignment: Alignment of the curriculum is essential for attaining student learning outcomes. There are two perspectives in curricular alignment. One is within the interaction between program structure and course structures, and the other is within the interaction between a specific lesson plan and student learning. To ensure that learning objectives become actual learning outcomes and thereby maximize students' learning, it is essential that the content, instructional strategies, learning activities, and assessment tasks that are used contribute to their realization.

To create a lesson that maximizes student learning, the MISSAL framework ensures that the content, learning activities, and formative assessments are all aligned with the desired student learning outcomes. For each unit of study, a curriculum blueprint agreed upon by the faculty is established. The blueprint is essential in the MISSAL approach, which places a premium on consistency and equity across faculty and students. The blueprint contains a topic overview, talking points, student learning outcomes, inputs, and itinerary.

Formative assessment: Assessment, which can be addressed in a variety of ways, enables instructors and students to track progress toward achieving learning outcomes. Whenever possible, evaluations should be founded on authentic work duties and should reflect the relevance and complexity of performance in the discipline. Assessment methods and instruments should be valid and reliable. Qualitative and quantitative data and multiple measurement techniques are essential. Both formative and summative decisions can be made using the same assessment data. Success criteria outline the necessary steps that learners must take to achieve the objectives of the given task or activity.

In the MISSAL approach, evaluation data is collected frequently. Formative assessment and feedback are a combined strategy in which faculty monitor/observe student performance, provide corrective feedback, and adjust teaching and/or learning strategies to improve students' performance, as needed. Merely exposing students to information does not guarantee their retention. To ensure that students are retaining, comprehending, and generalizing new concepts, individual and collective student development is frequently assessed in a variety of ways and at various times. Formative assessment evaluates students' progress throughout the course and each module to identify areas for improvement. This is assessment for learning in addition to assessment of learning. By systematically utilizing formative assessment, faculty will gain a better understanding of students' learning needs and be able to hone their instruction.

Table 1: Active ingredients of the MISSAL approach.

Focus area	Subcategories	Implementation in MISSAL
Focus on outcomes	Student learning outcomes	Learning target
	Constructive alignment	Lesson structure
Emphasis on mastery-learning	Cognitive load	Input
	Formative assessment	Diagnostic testing and practice
	Feedback	Formative assessment and metacognitive reflection
	Retrieval practice	Throughout curriculum
Promotion of learner-centeredness	Active learning	Preponderance of the lesson
	Mindset	Casual-style explanation and facilitation
	Metacognition	Metacognitive reflection
	Self-regulated learning	Input/initial and intervening phases of learning
	Scaffolding	Throughout the curriculum

In both the initial and intervening learning phases, the MISSAL approach includes formative assessments, including diagnostic testing. Students take a diagnostic test at least until midterm to measure their conceptual understanding of introductory knowledge and to activate the testing effect, which research reveals has a substantial influence on brain development and long-term memory. Throughout the lesson, individual students and structured groups are assessed informally.

Feedback: It is essential to assess students' comprehension and provide them with consistent, clear feedback. Students can receive feedback from educators, peers, computer-assisted technology, and themselves. The purposes of feedback are to motivate students, inform them of their performance in learning, and demonstrate how they can further develop. To accomplish these objectives, feedback must be timely, explicit, centered on strategy rather than ability or effort, and proportional to the complexity of the task at hand [8]. In addition, timely feedback prevents students from wasting time practicing errors or operating under incorrect knowledge.

Throughout and upon completion of learning in the MISSAL model, learners receive feedback on their accomplishments. After completing diagnostic testing, for instance, students receive computer-mediated corrective feedback. Immediately thereafter, the instructor examines each assessment question with students to enhance their critical thinking skills, dispel misconceptions, assist them in making connections to prior learning, and, if necessary, provide additional information. Students also receive feedback *via* participation in metacognitive activities.

Mastery learning and focus on abilities

According to the principles of mastery learning, it is essential for students to attain a certain level of proficiency in foundational information before progressing to acquire further knowledge on subject matter [9]. Undoubtedly, education requires the delivery of an abundance of academic input; students should be engaged, inspired, and informed by it. Educational content should be both practical and practicable.

Managing cognitive load: The nature of learning necessitates that students can retain, recall, apply, and then transfer newly acquired knowledge in a variety of contexts. Cognitive load theory and research on the topic have implications for teaching and learning in higher education. Sweller defines cognitive load as the thought processes required for working memory to engage in learning activity [10]. According to cognitive load theory, learning processes are a function of working memory activities with finite capacity and duration [11]. Memory becomes overloaded and limits learning when activities surpass working memory capacity. More specifically, cognitive load theory contends that instructional design must account for the constraints of the human cognitive architecture to prevent needlessly overloading a learner's working memory [12]. Intrinsic cognitive load refers to thinking processes focused on acquiring the knowledge and/or abilities at hand. Existing literature and instructor feedback indicate that students are less likely to achieve deep understanding of course information when they are overwhelmed with excessive reading and lecture notes. Furthermore, content-heavy, lecture-based instruction tends to turn students into passive learners. In both phases of learning, students are exposed to content i.e., input. Initially, students undertake required reading, review videos, listen to podcasts, and etcetera on their own. Following that, they engage in instructor-led information dissemination and facilitation. The most important and distinct (memorable) components of content are included in the curriculum at each stage, as highly distinct material is remembered more readily and precisely. For instructor-led input, the content to be learned is chunked to enhance long-term retention and recall by managing the quantity and organization of content dissemination. There are numerous methods for recoding information into easily remembered chunks.

Extraneous cognitive load, on the other hand, relates to the cognitive work invested in navigating the instructional design. Attending is a critical component of learning; students cannot recall what they do not notice. Therefore, ensuring that students are paying attention to the instruction is essential. Moreover, attending to critical components of a lecture or an assignment is necessary to preventing information overload. This requires faculty's ability to draw learners' attention to important ideas while ignoring extraneous material that may surround them. Furthermore, extraneous cognitive load encompasses the mental effort used by students to navigate and comprehend the various components of a lesson. Consequently, it is imperative for educators to meticulously structure each lesson, ensuring that instructions, activities, content delivery, and evaluation are presented in a manner that is readily comprehensible and executable for students.

Lesson structure is an essential component of the MISSAL approach. Each lesson plan in this paradigm consists of two learning phases and five components. The activity instructions and scaffolding are explicit, succinct, direct, and written in language that is student friendly. Likewise, for content posted on the learning management system. Lesson structure enables the instructor to guide students through the material to be covered so that they are not overburdened and receive the necessary support for growth and success.

Retrieval practice: Memory, comprehension, procedural knowledge, and deep learning all require practice. The frequency with which something is attended to often determine how long and effectively it is remembered in one's long-term memory. It is essential to incorporate regular retrieval practice and rehearsal into the curriculum. Retrieval practice is useful for both teaching and learning. Restudying the same material is not as effective for long-term retention and persistent learning as actively recalling previously taught material. This empirical occurrence is referred to as retrieval practice or the "testing effect." Over the past century, studies have consistently found that retrieval practice has a large and positive effect on memory and learning [12-16].

Recovery of knowledge helps memory and learning in two different ways. According to preliminary research, testing helps students remember material they have already learned. In other words, when compared to restudying, taking a test (i.e., retrieval practice) improves recall of studied material. The reverse testing effect is the term used to describe this. Further studies have discovered that retrieval practice has the potential to enhance the recall, comprehension, transferability, and integration of new, unlearned material as well. In other words, testing (retrieval practice) on previously learned material makes it easier to learn new material later on (i.e., forward testing effect).

An important aspect of retrieval practice is the way it encourages active learning participation in memory retrieval and encoding. Rereading, reviewing, taking notes, underlining, studying beforehand, and lecturing, to mention a few, are traditional and often used learning techniques that are characterized by passive encoding and no active memory retrieval [17,18]. In the MISSAL approach retrieval practice is a potent catalyst for improving students' long-term memory and developing their conceptual understanding. Therefore, in this model, students practice retrieval skills on a regular basis. This occurs both during the first phase of learning with diagnostic testing and throughout the intervening phase.

Promotion of learner-centeredness

As a learner-centered method, retrieval-based learning is a significant part of the MISSAL paradigm because it engages students and helps them retain their knowledge, which is required for comprehension, application, and higher-order thinking. The term "learner-centeredness" pertains to instructional approaches that facilitate active participation of learners in educational activities. Students are encouraged and expected to participate actively in their learning by asking questions, finding connections, participating in introspective and metacognitive reflection, and reporting on their progress in a learner-centered approach. Putting the learner at the center of the learning process, emphasizing active learning, and promoting a collaborative and supportive learning environment are among the key concepts of this strategy. Rather than just imparting information, the educator's responsibility in a learner-centered "classroom" is to function as a facilitator, guide, and coach.

Active learning: The concept of active learning holds major significance within the MISSAL method. Active learning places a greater emphasis on the cognitive, affective, and behavioral development of students rather than solely focusing on the acquisition of factual knowledge and the transmission of information. Students who receive an education dominated by lectures and other didactic teaching methods are likely to be primarily passive learners. The traditional learning environment in higher education, which underscores a constant lecture-style, limits student participation in their learning as well as how they learn. In active learning, students engage in discussions, simulations, research, critical thinking, and cooperative group exercises to develop higher-order thinking skills like analysis, evaluation, and synthesis. A few examples of instructional techniques that adhere to this learner-centered concept are inquiry-based learning, problem-based learning, experiential learning, cooperative learning, and service learning.

The benefits of active learning can be summed up as: Promoting the development of higher-order thinking skills and adaptive performance, supporting self-directed learning, fostering students' interaction with each other and faculty, allowing students to think about and process information, encouraging students to connect academic content to practical use, and fostering a more positive attitude towards learning [19-23]. The extant literature suggests when learners are empowered using an appropriate teaching methodology, they experience learning gains in addition to a sense of confidence, capability, competence, and self-esteem, enabling them to face their learning as well as life's challenges with greater effectiveness [19-22,24,25].

MISSAL is an active learning technique in which students actively participate throughout each course. Activities range from a brief participatory moment during an instructor-led/facilitated session to activities that are totally student-centered. Students are encouraged and expected to participate actively in their learning by, among other things, asking questions, making connections, engaging in introspective and metacognitive reflection, and reporting on their progress.

Metacognition, mindset and self-regulated learning

From the perspective of MISSAL, active learning has a critical function in fostering academic and professional competence in students because it enables them to assume ownership of their learning process through engagement in both practical application and critical reflection. We learn about learning as we acquire factual, conceptual, and procedural knowledge. Metacognition is the understanding of our own cognitive processes; it consists of being aware of our thinking (cognitive monitoring) and controlling our thinking in relation to learning in addition to the learning methods used (cognitive regulation). Metacognition skills enable students to direct, monitor, assess, and alter their ongoing learning. Metacognition is linked to self-regulation or self-regulated learning. Self-regulation refers to the learning that results from a student's belief that he or she is capable of learning in ways that promote self-generated thoughts and behaviors that are systematically geared toward achieving their learning objectives. The goal of self-regulated learning is to assist students in defining their own learning goals, monitoring their own study habits, and making decisions and choices that contribute to the achievement of those goals. It requires self-awareness, the motivation to exert effort and to persist in the face of difficulty, the ability to limit anxiety about task difficulty, the operationalization of short and long-term objectives and the setting of priorities among them, and the ability to deal with unexpected barriers and find solutions.

Research and theory support the relationship between self-regulation and student achievement [23,26,27]. Certain forms of instructional practices have been found to be the most effective for promoting self-regulated learning, according to classroom-based research [28]. These practices include explicit teaching and modeling of self-regulation strategies, including explicit feedback that links increased performance with specific strategies employed (i.e., enhanced metacognitive awareness), and gradually decreasing the support provided by the teacher so that students begin to internalize or self-regulate their learning (i.e., gradual release of responsibility).

MISSAL incorporates learning to learn into the curriculum to encourage students to pursue and persist in learning, to organize their own learning, to assess their progress and further learning requirements, and to refine their academic habits. Students receive examples and explanations of effective study strategies and the science of learning in a casual manner. At the conclusion of each lesson, they are encouraged to engage in self-reflection regarding their learning. MISSAL upholds rigorous educational standards and expectations for exceptional student performance to combat fixed mindset, enhance students' academic self-efficacy, and preclude potential stereotype threat and/or imposter syndrome.

Scaffolding: Scaffolding, also known as cognitive bootstrapping, is an important component of deep learning in general and self-regulated learning in particular. Scaffolding derives from the cognitive apprenticeship theory, which emphasizes the social context of learning and the interaction between experts and learners and has origins in Vygotsky's concept of the zone of proximal development [29]. As an instructional strategy, scaffolding focuses on providing learners with short-term assistance for difficult task components. The support may take the form of offering suggestions, providing direct assistance, adjusting the level of difficulty of tasks, highlighting crucial elements, providing prompts or cues, sustaining learners' interest, providing feedback, modeling, coaching, providing explanations, and utilizing structured groups/ partnerships. It should be provided when students need support, which can make encoding of the new information easier. The precise nature of the scaffolds is determined by the target learning objective(s) in addition to the needs of students and should be removed once mastery is demonstrated.

The structure of each lesson in MISSAL which constitutes instructional scaffolding provides students with learning support. They are provided with resources that contain information about a specific topic or facilitate the processing of to-be-acquired knowledge and skills (Table 2).

MATERIALS AND METHODS

The objective of this study was to assess the efficacy of the MISSAL approach in enhancing the retention and recall of acquired knowledge among students who are enrolled in a course that involves a substantial amount of content. Specifically, this study addresses the following question: To what extent can the MISSAL approach facilitate short and long-term knowledge retention and recall of acquired learning, successful exam performance, and learning gains among students enrolled in a content-intensive course?

Predicted student performance outcomes

Drawing upon the extant scholarly literature pertaining to the Scholarship of Teaching and Learning (SoTL) as well as the insights derived from neuroscience about the cognitive processes and brain development involved in learning, it is expected that the following outcomes would be observed:

Hypothesis 1: It is expected that students will achieve marginally higher scores on pre-test quizzes (i.e. diagnostic testing) compared to their performance on the midterm examination.

Hypothesis 2: There will be considerable improvement in students' performance on the final exam compared to their performance on the midterm assessment.

Hypothesis 3: It is expected that students will demonstrate moderate to high levels of learning gains by the conclusion of the course.

Participants

The sample for this research comprised undergraduate social work students who were enrolled in the lone section of a course called "Human Behavior and the Social Environment" at a four-year university in New York City. This university serves a diverse student population, including a significant number of first-generation college students as well as those from Black and Latinx backgrounds. The study was conducted during the spring semester of 2023. The present study obtained exempt clearance from the Institutional Review Board (IRB) of the university and followed all ethical rules pertaining to the handling of human participants.

Research design

To address the research inquiries of this study, a repeated measures design was employed. A total of 14 students enrolled in the course, but two cases were excluded from the study due to incomplete data. The final sample size consisted of 12 students.

Outcomes assessments

In this study, the instructor-of-record administered a brief, informal test of knowledge with immediate feedback one week after the initial learning phase. The effect of the MISSAL approach on short-term memory was examined by quizzing students on actual educational material seven days after independent study for each unit of learning. In the following class session, a 10-item multiple choice quiz representing the most essential content from the respective lessons was administered to students.

Quizzes were developed by the instructor of record using the test bank for the required textbook for the course. Each correct response was worth 10 points; the maximum score for each quiz was 100%. Quizzes were administered to student's in-class *via* a learning management system. Following the completion of the assessment, students were given computer-mediated feedback that included the original question as well as the correct response. Immediately thereafter, the instructor reviewed each assessment question with students to refine their critical thinking skills, dispel misconceptions, assist them in making connections to prior learning, and if necessary, provide additional information. Five data points were collected to measure short-term memory, and their sum was used as the pretest score in the analysis of learning gains (Table 3).

Table 2: Lesson structure and course curriculum in MISSAL.

Phases of learning	Components for learning	Implementation in MISSAL
Initial phase of learning	Learning target	Students informed about the target learning outcome and success criteria.
	Initial input	Students engage in independent learning of introductory knowledge.
	Diagnostic testing	In the beginning of the class meeting, students participate in diagnostic testing (at least until midterm).
Intervening phase of learning	Mental set	Students are presented with a brief activity or prompt that focuses the students' attention before the instructor-led/facilitated input begins.
	Intervening input	Micro instruction provided by the instructor to ensure students has the conceptual understanding necessary to engage in scheduled practice and formative assessment.
	Scheduled practice	Based on the input, students complete at least one practice exercise.
	Formative assessment	An assessment of and for learning is administered.
	Metacognitive reflection	Students are encouraged to reflect on their learning.

Table 3: The following schedule of testing and data collection was used for this investigation.

Week/Unit	Intervention	Testing and Data collection
Week #1	Week #1 Instructional input (i.e., lecture, reading, activities, etc.)	No retrieval-based testing
Week #2	Week #2 Instructional input (i.e., lecture, reading, activities, etc.)	Quiz on week #1 content
Week #3	Week #3 Instructional input (i.e., lecture, reading, activities, etc.)	Quiz on week #2 content
Week #4	Week #4 Instructional input (i.e., lecture, reading, activities, etc.)	Quiz on week #3 content
Week #5	Week #5 Instructional input (i.e., lecture, reading, activities, etc.)	Quiz on week #4 content
Week #6	Week #6 Instructional input (i.e., lecture, reading, activities, etc.)	Quiz on week #5 content

In addition, the efficacy of the MISSAL method on students' long-term knowledge retention and recall of acquired learning at seven weeks and performance on high-stakes assessments (i.e., durable learning) was evaluated using a midterm exam. The midterm exam was administered to students in the classroom *via* a learning management system during week seven of the semester. The test consisted of 50 multiple choice items representing the most important information from the beginning of the course up until the date of the midterm examination. Each correct response was worth two points; the maximum score was 100%. Following the completion of the midterm exam, students were provided with computer-mediated feedback that included the original question as well as the correct response. In addition, the instructor had students complete a post-exam wrapper and encouraged independent post-exam review.

A semi-cumulative final exam was also used to assess the effect of the MISSAL strategy on students' long-term knowledge retention and recall of acquired learning at seven weeks and performance on high-stakes assessments in this study. The final consisted of 50 multiple choice items representing the most important information from the midterm to the end of the course. The final exam was administered in-class *via* the learning management system during week fifteen of the semester. Each correct response was worth two points; the maximum score for this assessment was 100%. Following the completion of the exam, students were given computer-mediated feedback that included the original question as well as the correct response. In addition, the instructor engaged students in a post-exam wrapper and encouraged them to conduct their own post-exam review.

Statistical methods

Students' raw quiz and exam scores were calculated by hand as well as by use of IBM Statistical Package for Social Science for Windows 26.0 for analysis, while the instructor of record determined the weighting of scores for the series of quizzes and high-stakes exams on final grading. However, educational scholars postulate that in the absence of a grade incentive, students may be disinclined to fully engage in testing; as a result, the instructor made quizzes and cumulative assessments worth at least 50% of the course grade [17]. This arrangement is fair and acceptable because testing for assessment is an objective and direct measure of student learning as well as an essential component of higher education.

There are several methods for measuring learning gains/retention and recall. According to scholars and statisticians, each has limitations. To overcome that problem, the four most popular calculations were used to analyze the proportion of knowledge that students remembered over the first half of the course; namely, normalized change (i.e., gain of averages and average of gains), normalized changed, and percent change.

In this study, knowledge retention and recall of acquired learning was defined as the average increase or decrease in students' mean pre-test quiz scores and mean midterm scores over the first seven weeks of the course. Normalized gain scores were calculated for the cohort (i.e. gain of averages) [30]. Additionally, gain scores for each student was computed and then averaged for the entire cohort to measure their average learning gain (i.e. average of gains) from the beginning of the course of study and through the series of weekly unit quizzes to the midpoint in the semester, seven weeks later (i.e. academic growth). Hake defines normalized gain, denoted as <g>, as the ratio of the pretest to posttest average gain. The formula below was used to calculate student academic growth, also known as learning gains/losses or academic progress.

$$\langle g\rangle = \frac{\langle post\rangle - \langle pre\rangle}{100 - \langle pre\rangle}$$

The following criteria were used to interpret <g>:

High gains >0.7,

Moderate gains 0.3-0.7,

Low gains <0.3

Marx and Cummings developed a metric known as normalized change scores, which serve as a student-level alternative to Hake's normalized gain measure [31]. The symbol c is used to represent normalized change scores. The following equation was employed to compute normalized change scores for the given sample.

$$c = \begin{Bmatrix} \dfrac{post - pre}{100 - pre} \\ drop \\ 0 \\ \dfrac{post - pre}{pre} \end{Bmatrix}$$

post>pre

post=pre=100 or 0

post=pre

post<pre

The following criteria were used to interpret <c>:

High gains >0.6,

Moderate gains 0.3-0.6,

Low gains <0.3

The percent change formula, which measures the change from pre to post-test and expresses the change as an increase or decrease, can also be used to assess learning gains. The following formula was used to calculate the variance in mean scores between pre and post-tests.

$$\% \text{change} = 100 \times \frac{(final - initial)}{(initial)}$$

These metrics are concise, quick, and simple for faculty to use for classroom-based research as well as monitoring students' development and the effectiveness of a lesson plan. A minimal improvement threshold of 5% change is established to reflect the value set for students' performance.

Finally, paired sample t-tests were performed to compare the mean quiz, midterm, and final exam scores. Learning gain scores and t-test analyses were utilized to investigate potential impacts of the MISSAL approach on students' knowledge retention and recall of acquired learning in an information-dense course.

RESULTS

A total of 12 learners successfully completed all the assessments. List of student-level mean quiz scores across each unit of learning. The average value of pre-test scores of cognitive knowledge for the pretest quizzes was 74.83. The average of the midterm exam scores for this sample was 77.67 (Tables 4 and 5).

The observed value for the gain of averages, denoted as <g>, was determined to be 0.12. Similarly, the average of gains, denoted as $< g^{ave} >$ was found to be 0.05. The normalized change, representing the relative change in value, denoted as c was calculated to be 0.14. The average final exam results were 90.67 (Table 6).

A paired-samples t-test was used to examine the relationship between pretest quiz scores and midterm exam scores among students. Once more, the average value of the pre-test quiz scores was found to be 74.83, with a standard deviation of 9.85. Similarly, the average score on the midterm examination was determined to be 77.67, with a standard deviation of 6.76. There was no statistically significant difference in memory and test performance between the pretest quizzing and midterm assessments ($t(11) = -1.252$, $p > .05$). There was slight improvement in test performance of 3 points, representing a percentage gain of 4%, when comparing diagnostic testing to the results of the midterm exam.

A paired-samples t-test was conducted to compare the average score obtained in the midterm examination with the average score achieved in the final exam. The average score on the midterm assessment was 77.67 with a standard deviation of 6.76, while the average score on the final exam was 90.67 with a standard deviation of 7.15. The analysis revealed a substantial rise in performance from the midterm to the final exam in the course ($t(11) = -8.100$, $p < .001$). Students evidenced notable improvement of 13 points, representing a gain of 16.67%, when comparing the midterm results to those of the final exam (Table 7) [32].

Table 4: Mean quiz scores across each unit of learning.

	N	Range	M	SD
Unit quit #1	12	50	74.17	15.64
Unit quiz #2	12	60	66.67	18.75
Unit quiz #3	12	50	77.5	17.65
Unit quiz #4	12	60	78.33	20.38
Unit quiz #5	12	40	77.5	12.15

Table 5: Mean scores for quizzing on each learning unit and the midterm.

Mean quiz score	Mean midterm score
74.83 (9.85)	77.67 (6.76)

Table 6: Changes in learning between unit quizzing and midterm.

Student	Midterm exam score (Posttest)	Quiz average score (Pretest)	Student gain score
1	70	74	-0.15
2	82	84	-0.13
3	74	78	-0.18
4	86	78	0.36
5	76	86	-0.71
6	80	80	0
7	76	70	0.2
8	86	80	0.3
9	64	50	0.28
10	76	80	-0.2
11	86	74	0.46
12	76	64	0.33
	Total average gain score		0.05

Table 7: Mean scores for high-stakes testing with and without quizzing on each learning unit.

Midterm (w/unit quizzing)	Final (w/o unit quizzing)
77.67 (6.76)	90.67 (7.15)

DISCUSSION

Initial findings provide evidence for the prospective effectiveness of MISSAL in attaining exceptional academic results for students. It was anticipated that students would attain somewhat elevated scores on diagnostic testing in comparison to their performance on the midterm examination. Based on the evaluation of normalized gain, normalized change, and percent change scores, as well as the t-test statistic, it can be concluded that there was no statistically significant distinction in memory and test performance when comparing the pretest quizzing and midterm assessments. A marginal increase of 3 points was observed in test performance, indicating a relative improvement of 4% when comparing the diagnostic testing outcomes with those of the midterm examination. Moreover, a substantial enhancement in students' performance on the final examination relative to their performance on the midterm assessment was postulated. This hypothesis was confirmed.

CONCLUSION

In conclusion, students were anticipated to have achieved substantial to moderate learning gains by the end of the course. The prediction was confirmed. The students' performance on the final examination was noticeably superior to that of the midterm. They demonstrated an increase of 13 points, which corresponds to a gain of 16.67%, when comparing their midterm scores to their final assessment scores. According to Bjork and Bjork's (2020) theory of metamemory and desirable difficulties, conditions of learning that cause performance to improve rapidly frequently fail to support long-term retention and transfer, whereas conditions that create challenges (i.e., difficulties) and slow the rate of apparent learning frequently optimize long-term retention and transfer.

Based on the evaluation of quiz and high-stakes exam scores, it is evident that MISSAL holds promise in improving student retention and recall of acquired knowledge, as well as enhancing test performance and learning gains. The observed results in this study can be attributed to the active ingredients and theoretical framework underlying the intervention, which contribute to its effectiveness in improving student learning outcomes.

LIMITATIONS AND FUTURE RESEARCH

The outcomes of this initial investigation are particularly noteworthy considering the small sample size, which could preclude significant findings from being extrapolated. Nevertheless, the small sample size, non-experimental methodology, and cross-sectional design of this investigation hinder the applicability of the conclusions.

MISSAL has potential to accomplish the national "completion agenda". Additionally, it is expected to maintain high quality education and training and to achieve outstanding student learning outcomes. If instructors across an academic program adopt this method in every course from start to finish, our graduates may be able to function at a level that is currently unthinkable intellectually and professionally. The use of this paradigm is recommended. However, questions remain about the efficacy, efficiency, and amenability of this framework. It is imperative to conduct experimental investigations into the advantages of this approach in various authentic classroom settings. This research is necessary to determine the limitations of this strategy and to ascertain the specific circumstances in which students would derive the most benefits from the MISSAL approach.

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