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Research Article

Improving Students' Vocabulary Mastery Through Digital Mind Mapping for Twelfth-Grade Students of SMA Negeri 1 Tanjung Palas

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Abstract. This classroom action research investigated the use of digital mind mapping through the *Miro* platform to enhance vocabulary mastery and classroom participation among twelfth-grade students at SMA Negeri 1 Tanjung Palas. The study was motivated by preliminary evidence showing students' reliance on direct translation, difficulty in retaining words, and hesitation in contextual usage. Conducted in two cycles of planning, action, observation, and reflection, the research involved 31 students of Class XII B. Data were collected through vocabulary tests, classroom observations, and semi-structured interviews, then analyzed both quantitatively and qualitatively. Results indicated gradual improvement in vocabulary mastery and learning processes. The class mean score increased from 42.26 in the pre-test to 68.63 after Cycle 1 and 77.66 after Cycle 2, with 77.42% of students achieving the Learning Objective Achievement Criteria (KKTP) of 75.00. The mean N-Gain of 0.61 reflected moderate improvement. Observational data revealed a shift from passive translation-based learning to active vocabulary organization using branches, colors, images, and contextual examples. Technical challenges in Cycle 1 were mitigated in Cycle 2 through structured templates and teacher scaffolding, resulting in more confident collaboration and contextualized sentence production. These findings suggest that digital mind mapping, when supported by equitable access and teacher guidance, can effectively improve vocabulary learning and reduce classroom anxiety.

Keywords: Action Research; Affective Filter; Digital Mind Mapping; Miro Platform; Vocabulary Mastery.

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1. Introduction

Vocabulary plays an essential role in developing listening, speaking, reading, and writing skills because it enables learners to comprehend information and communicate ideas effectively (Putranti & Setyaningsih, 2022). At the senior high school level, vocabulary mastery extends beyond memorizing meanings to understanding word form, meaning, and use in appropriate contexts. These three aspects became the basis for identifying the learning problems in this research.

The study was conducted in Class XII B of SMA Negeri 1 Tanjung Palas during the 2025/2026 academic year, involving 31 students with diverse vocabulary abilities and unequal access to digital devices and internet connectivity. Initial classroom observations, formative assessments, students' participation, and a vocabulary pre-test revealed that the average score was only 42.26, considerably lower than the school's KKTP of 75.00. Students frequently depended on teacher translation, struggled to understand unfamiliar words independently, and tended to memorize isolated vocabulary without connecting it to contextual examples.

The classroom findings indicated that the primary issue was not merely low achievement but limited vocabulary retention and application. Although many students could recognize

translated words, they often failed to recall or use them appropriately in oral and written communication. Uncertainty regarding spelling, pronunciation, and meaning also reduced students' willingness to participate actively in classroom discussions. These observations suggested the need for an instructional approach that could strengthen vocabulary organization while encouraging greater confidence and participation, without claiming to measure the affective filter as a psychological construct.

Several instructional alternatives, including vocabulary lists, flashcards, word games, semantic mapping, and Digital Mind Mapping, were considered. Vocabulary lists mainly supported short-term memorization, whereas flashcards and games attracted students' attention but provided limited opportunities to visualize relationships among vocabulary components. Digital Mind Mapping using Miro was selected because it integrates semantic organization, visual representation, collaborative learning, and editable learning materials within a shared digital platform. Moreover, students were already familiar with smartphones, allowing teachers to modify learning templates across research cycles according to classroom needs.

Rather than being regarded as a universally superior strategy, Digital Mind Mapping was implemented as a context-specific solution. Its branching structure enabled students to associate target vocabulary with spelling, affixes, meanings, synonyms or antonyms, and contextual sentence examples. Visual elements such as colors and images supported memory retrieval, while collaborative activities encouraged peer explanation and feedback. Nevertheless, challenges including unstable internet access, unequal device performance, and varying familiarity with Miro were recognized as part of the Classroom Action Research process rather than experimental control variables.

The research adopted Classroom Action Research because its purpose was to improve teaching practice through continuous cycles of planning, implementation, observation, and reflection instead of comparing treatment groups. Findings from the first cycle informed revisions for the second cycle, including the use of structured Miro templates, simplified technical instructions, and more focused teacher guidance. Therefore, this study, entitled *Improving Students' Vocabulary Mastery through Digital Mind Mapping for Twelfth-Grade Students of SMA Negeri 1 Tanjung Palas*, explored students' experiences with Digital Mind Mapping through Miro, examined improvements in vocabulary mastery across form, meaning, and use, and reflected on how instructional adjustments enhanced the learning process under the local classroom context.

Based on the preliminary findings, several problems affecting students' vocabulary mastery at SMA Negeri 1 Tanjung Palas were identified. Students achieved a pre-test mean score of only 42.26, which was below the KKTP standard of 75.00, indicating difficulties in recognizing, retaining, and applying vocabulary independently. They also relied heavily on teacher translation and isolated vocabulary lists rather than contextual understanding or semantic relationships. Limited confidence caused many students to hesitate when answering questions or using unfamiliar vocabulary because they were uncertain about spelling, pronunciation, meaning, and sentence construction. In addition, previous learning activities using vocabulary lists primarily promoted short-term memorization and provided little opportunity for visual organization, collaboration, or contextual application. The classroom context was further influenced by unequal access to digital devices, unstable internet connections, and varying levels of familiarity with digital learning platforms, all of which needed to be considered throughout the implementation and revision of the classroom action.

This research aimed to examine how the implementation and continuous refinement of Digital Mind Mapping using Miro contributed to improving students' vocabulary mastery in terms of form, meaning, and use throughout two cycles of Classroom Action Research. In addition, the study sought to describe changes in students' classroom participation, collaborative learning, confidence, and observable classroom anxiety during the implementation of Digital Mind Mapping, providing insights into both the learning process and the development of students' vocabulary performance.

2. Literature Review

Vocabulary is a fundamental component of language learning because it underpins learners' ability to develop the four English language skills: listening, speaking, reading, and writing. It functions as the basis of communicative competence, enabling learners to understand information and express ideas effectively in the target language (Alagozlu & Kiymazarslan, 2020). Vocabulary refers to the collection of words within a language or the

words known and used by an individual in particular contexts (Maylani, 2021). Therefore, vocabulary mastery is not limited to recognizing words but also includes understanding their meanings and appropriate use.

Insufficient vocabulary limits learners' ability to comprehend spoken or written texts and prevents them from communicating effectively. Students who encounter unfamiliar vocabulary often struggle to understand the overall meaning of texts and participate actively in conversations. Since language acquisition begins with learning individual words before progressing to more complex communication, vocabulary becomes the foundation for acquiring additional language skills (Kami, 2023). Consequently, vocabulary learning plays a crucial role in enabling learners to process information and communicate successfully.

For senior high school students, vocabulary mastery is essential because it supports academic achievement and communication in both spoken and written forms. Learners with broader vocabulary knowledge can understand learning materials more effectively and express their ideas with greater confidence. Conversely, limited vocabulary restricts their ability to communicate accurately and fluently (Nadia et al., 2022). Therefore, vocabulary should be viewed as a combination of words, meanings, and appropriate usage that enables meaningful communication and supports the development of overall language proficiency.

Cognitive psychology also explains the benefits of digital mind mapping through Dual Coding Theory. Paivio (1991) argues that information is retained more effectively when verbal and visual representations are processed simultaneously. During digital mind mapping, learners combine textual information with images, colors, and visual connections, creating stronger cognitive associations. Kim and Hartono (2024) reported that students using digital mind mapping achieved higher vocabulary recall than those employing conventional note-taking techniques. Nevertheless, visual representations alone do not automatically improve learning. Teachers should ensure that images, colors, and connections represent meaningful relationships rather than decorative elements and gradually reduce instructional support as learners become more independent.

The issue of the digital divide extends beyond internet availability to include disparities in device quality, digital literacy, technical support, and opportunities for meaningful technology use. To promote digital equity, teachers should provide flexible learning arrangements, shared devices, downloadable materials, and alternative non-digital activities when technological access is limited. Considering these factors, digital mind mapping represents a theoretically grounded, cognitively effective, and contextually appropriate approach to vocabulary learning. Supported by cognitive, constructivist, and sociocultural theories, Miro strengthens vocabulary acquisition through visual organization, collaboration, and learner engagement, making it suitable for achieving both academic success and digital literacy (Zhang & Choi, 2023).

Vocabulary consists of words that individuals understand and use for communication. Learning vocabulary involves not only recognizing word forms but also understanding their meanings and applying them appropriately in different situations. According to Haycraft, as cited in Hatch and Brown (Alqahtani, 2015), vocabulary is classified into two categories: receptive vocabulary and productive vocabulary.

Vocabulary learning involves more than memorizing words because effective word knowledge requires understanding form, meaning, and use. Nation (2013) explains that these three dimensions are interconnected and must be mastered both receptively and productively. Comprehensive vocabulary knowledge enables learners to recognize words, understand their meanings, and apply them accurately in authentic communication.

Language acquisition is influenced not only by cognitive ability but also by learners' psychological and emotional conditions. Vocabulary learning becomes more effective when students experience a supportive classroom atmosphere that reduces emotional barriers. One of the most influential theories explaining this relationship is the Affective Filter Hypothesis proposed by Krashen (1982). The theory explains that language input can only be successfully processed when learners' emotional states allow them to receive and internalize new information. Therefore, cognitive ability alone is insufficient if affective factors hinder the learning process.

According to Krashen (1982), the affective filter is shaped by three interconnected variables: anxiety, motivation, and self-confidence. High anxiety creates psychological barriers that limit language acquisition, whereas a relaxed learning environment enables learners to absorb new vocabulary more effectively. Motivation encourages active participation and persistence in learning, while self-confidence increases students' willingness to communicate

and learn from mistakes. Consequently, reducing anxiety while strengthening motivation and confidence becomes essential for successful vocabulary acquisition.

To lower the affective filter, teachers should create engaging, low-pressure learning environments. The integration of digital visual platforms such as Miro supports this objective by providing collaborative and interactive learning experiences. Through visual activities and collaborative tasks, students become more motivated, confident, and receptive to learning, allowing English vocabulary to be processed and retained more effectively (Krashen, 1982).

The term mind mapping combines the words *mind* and *mapping*. According to the Oxford Dictionary (2025), *mind* refers to the human capacity for thinking, feeling, and awareness, while *mapping* refers to the visual representation of information or spatial relationships. Therefore, mind mapping can be understood as a visual technique for organizing ideas, concepts, and information through interconnected diagrams.

Mind mapping functions as an effective note-taking strategy by combining words, images, symbols, colors, and connections to facilitate information processing. This technique improves comprehension, supports long-term memory, and enhances information retrieval because it stimulates creativity and engages both hemispheres of the brain (Kratz, 2021). Its visual structure reflects the brain's natural way of processing information, making it easier to understand and remember concepts compared to purely verbal explanations (Nia, 2019).

Mind maps are generally categorized into traditional mind maps, created manually on paper, and digital mind maps, developed using software or online applications. Digital mind mapping enhances productivity by supporting idea generation, organization, evaluation, and information retrieval through interactive technology (Bhattacharya & Mohalik, 2020). Compared with conventional note-taking, digital mind mapping provides richer visualization and stronger support for learning and academic performance (Abbaspour et al., 2019).

Among these applications, Miro is selected for this study because it combines digital mind mapping with real-time collaboration. Miro provides an interactive online whiteboard where students can simultaneously create, organize, and connect vocabulary using text, images, shapes, colors, and multimedia resources. The platform also integrates with various educational applications, making it suitable for collaborative learning environments (Bhattacharya & Mohalik, 2020). Through these visual and collaborative features, Miro promotes creativity, increases student engagement, and supports vocabulary retention more effectively than traditional learning methods.

Overall, digital mind mapping represents an innovative approach that transforms vocabulary learning into a more interactive, accessible, and learner-centered experience. Its flexibility allows teachers to accommodate different learning styles while encouraging active participation and meaningful knowledge construction. Therefore, integrating digital mind mapping into classroom instruction can improve vocabulary mastery and foster technology-enhanced learning that is relevant to contemporary educational needs (Bhattacharya & Mohalik, 2020).

For vocabulary instruction, Zhang and Choi (2023) propose a six-stage instructional framework that integrates mind mapping with Miro. The process begins by placing the central topic at the center of the board, followed by adding key vocabulary items as branches. Students then enrich each vocabulary item with meanings, synonyms, antonyms, parts of speech, and example sentences while incorporating images or multimedia resources. Color coding, icons, and visual symbols are used to strengthen memory associations. Students subsequently review one another's work through peer feedback and discussion before the teacher conducts formative assessment and saves the completed mind map for future learning.

This study adopts the instructional model developed by Zhang and Choi (2023) because it provides a systematic sequence that encourages visualization, collaboration, and active vocabulary construction. Through the integration of digital mind mapping in Miro, vocabulary learning shifts from simple memorization to an interactive and multi-sensory learning process that strengthens understanding, retention, and student engagement.

3. Research Methods

This study adopted Classroom Action Research (CAR) because it aimed to address an ongoing instructional problem within the researcher's own classroom through a continuous process of improvement. CAR emphasizes practitioner inquiry, enabling teachers to refine instructional practices through repeated cycles of planning, acting, observing, and reflecting, where findings from one cycle guide revisions in the next (Kemmis & McTaggart, 1988).

Unlike a quasi-experimental design that primarily measures treatment effects by comparing groups, this research focused on improving the learning process in Class XII B, identifying classroom challenges, modifying instructional strategies, and reflecting on both teacher and student experiences. Students' achievement scores were interpreted alongside classroom observations, interviews, and reflective notes to provide a comprehensive understanding of the intervention. The study followed the CAR model proposed by Kemmis and McTaggart, as illustrated by Nanda et al. (2021), in which the completion of one cycle may reveal new issues that require subsequent cycles for continuous instructional improvement.

The research was conducted during the odd semester of the 2025/2026 academic year, specifically throughout November 2025. The implementation lasted approximately one month and consisted of two complete CAR cycles encompassing six classroom meetings. This schedule allowed sufficient time to implement the instructional intervention, evaluate students' vocabulary development, and refine teaching practices through the iterative stages of planning, acting, observing, and reflecting (Kemmis & McTaggart, 1988).

The study took place at SMA Negeri 1 Tanjung Palas, a public senior high school located in Tanjung Palas District, Bulungan Regency, North Kalimantan. The school was selected because it represented the researcher's teaching environment, where recurring vocabulary-learning difficulties had been identified in Class XII B during regular instruction. Conducting the research in the researcher's own classroom facilitated continuous observation, immediate reflection, and timely instructional adjustments. The school provides adequate educational facilities, including classrooms, science and computer laboratories, a library, teachers' workspaces, sports facilities, a student organization room, and a prayer area, all of which support both academic and personal development. During the 2025/2026 academic year, the school enrolled 616 students distributed across Grades 10, 11, and 12, with each grade consisting of approximately six classes containing 29–36 students, creating a well-organized learning environment.

The research participants were 31 students of Class XII B, consisting of 4 male and 27 female students, who were taught directly by the researcher. In accordance with the principles of Classroom Action Research, these participants were not intended to represent the wider twelfth-grade population but served as the focus of instructional improvement because recurring vocabulary-learning problems had been identified through classroom observations, teaching records, and a diagnostic pre-test.

This study adopted a triangulated data collection approach by integrating tests, classroom observations, and semi-structured interviews to comprehensively examine the effectiveness of Digital Mind Mapping in improving students' vocabulary mastery. The combination of quantitative and qualitative instruments enhanced the credibility of the findings by capturing learning outcomes, classroom behavior, and students' perceptions from multiple perspectives. The vocabulary tests measured students' achievement before and after the intervention, observations documented classroom engagement and the implementation process, while interviews explored students' experiences, challenges, and opinions regarding the use of digital mind mapping. The integration of these instruments strengthened the validity of the study through methodological triangulation (Creswell & Guetterman, 2021).

The study employed a mixed-methods approach by integrating quantitative and qualitative analyses. For quantitative data, students' vocabulary scores were calculated using the standardized scoring formula proposed by Sugiyono (2019), where the final score was obtained by dividing the raw score by the maximum possible score and converting it into a percentage. To evaluate overall class performance, the researcher calculated the mean score by dividing the total of all individual scores by the number of students (Sugiyono, 2019). To ensure methodological rigor, the study addressed both validity and reliability of the research instruments and procedures.

4. Results and Discussion

Findings

Classroom observations in Class XII B of SMA Negeri 1 Tanjung Palas showed that students demonstrated limited participation throughout the learning process. During the pre-activity, the teacher attempted to activate prior knowledge by presenting a short video about a "friendly future" and asking students to write several English words related to the topic. However, only a few students were able to produce vocabulary independently, while most depended on dictionaries or waited for the teacher's translation. Instead of inferring meaning from visual context, students frequently requested direct translations, indicating poor

vocabulary retention and limited lexical independence. Such dependence reflects insufficient semantic processing, which weakens long-term vocabulary acquisition (Nation, 2013).

During the core activities, the teacher introduced a diagnostic game (Jumping Frog on Educaplay) before distributing a narrative text entitled "The Story of a Friendly Future." Although students made numerous errors during the game, they participated more actively and showed greater enthusiasm when interacting with visual and game-based activities. This observation suggests that visual and interactive learning environments may increase engagement and support vocabulary learning by reducing cognitive barriers (Mayer, 2021). Nevertheless, after the activity the teacher returned to the conventional practice of providing isolated vocabulary lists for memorization, which did not improve students' confidence or comprehension.

Students also experienced considerable anxiety when required to read aloud or communicate in English. They hesitated because they were uncertain about pronunciation and feared making mistakes, particularly due to the differences between English spelling and pronunciation. Consequently, mispronunciations were common, students avoided speaking, and classroom interaction remained minimal. Interview data further confirmed that memorizing vocabulary without contextual application caused students to forget word meanings quickly and left them unsure of how to use new vocabulary appropriately in sentences. This finding supports previous research emphasizing that meaningful contextual practice is essential for vocabulary retention and language production (Nation, 2013).

Group discussions and classroom presentations further demonstrated students' limited vocabulary mastery. Although students completed worksheet tasks collaboratively, they were reluctant to present their findings orally because of low confidence and inadequate lexical knowledge. Similarly, reflective questions at the end of the lesson received almost no response, creating a passive classroom atmosphere. The final classroom quiz also reflected these difficulties, with only 2 out of 31 students achieving the Learning Objective Achievement Criteria (KKTP), while 29 students failed to meet the required standard. These results indicate a substantial discrepancy between the expected learning outcomes and students' actual vocabulary competence.

Overall, the reconnaissance findings indicate that the conventional vocabulary instruction was ineffective in promoting long-term retention, contextual vocabulary use, and communicative confidence. Instead, students responded more positively to visual and interactive learning activities, suggesting that a spatial-visual approach, such as Digital Mind Mapping, could better support vocabulary organization, semantic retention, and classroom participation (Mayer, 2021).

Student participation also remained consistently low during classroom activities. Learners displayed limited confidence when reading aloud, largely because they feared mispronunciation and mistakes arising from differences between English spelling and pronunciation. This high affective filter reduced students' willingness to communicate and contributed to a passive learning environment. In contrast, students demonstrated noticeably greater enthusiasm when participating in the Jumping Frog activity on Educaplay, suggesting that interactive visual media can increase motivation and reduce learning anxiety (Krashen, 1982).

The observation further showed that students' insufficient vocabulary knowledge prevented them from participating actively in discussions, presentations, and lesson reflections. Conventional translation-based instruction failed to create meaningful learning experiences and instead contributed to disengagement and boredom. Therefore, implementing a spatial-visual learning strategy, particularly Digital Mind Mapping, was considered necessary to facilitate vocabulary organization, strengthen semantic memory, improve learner confidence, and create a more engaging classroom environment (Mayer, 2021).

Following the qualitative investigation, a formal pre-test was administered on November 10, 2025, involving 31 students. The assessment consisted of 30 items, including 10 multiple-choice questions, 10 matching tasks, and 10 translation items, to measure students' initial vocabulary mastery before the implementation of Digital Mind Mapping.

The quantitative findings demonstrated that students' initial vocabulary proficiency was considerably below the expected standard. The class obtained a mean score of 42.26, substantially lower than the KKTP. Only 2 students (6.45%) achieved the passing grade, whereas 29 students (93.55%) failed, confirming that vocabulary mastery was inadequate prior to the intervention.

A closer examination of each test component revealed similar weaknesses across vocabulary skills. Students achieved mean scores of 3.94/10 in Multiple Choice (39.4%) and 3.39/10 in Matching (33.9%), indicating serious difficulties in recognizing vocabulary items and associating words with their meanings. Although the Translation section produced the highest average (9.58/20, equivalent to 47.9%), the result remained below satisfactory performance. Collectively, these findings quantitatively supported the qualitative observations by demonstrating that students possessed limited vocabulary knowledge and required a more effective instructional approach. Therefore, the implementation of Digital Mind Mapping was considered necessary to improve vocabulary acquisition, semantic retention, and overall learning outcomes (Mayer, 2021).

Based on the preliminary findings, the most urgent issue was the students' limited vocabulary mastery. The pre-test demonstrated weak performance, with a mean score of 42.26 and a failure rate of 93.55%, while the Multiple Choice and Matching sections produced the lowest results. Interview data further indicated that students mainly depended on memorizing isolated vocabulary and direct translation, strategies that did not promote long-term retention or effective sentence construction. These findings suggest that vocabulary instruction should move beyond rote learning toward a visual and relational approach. A spatial-visual strategy enables learners to connect word meaning, grammatical form, and contextual use, thereby strengthening conceptual understanding and vocabulary retention (Buzan, 2018).

Considering these cognitive and emotional barriers, traditional translation-based instruction was insufficient for fostering independent vocabulary development. Therefore, Digital Mind Mapping through the Miro application was selected as the instructional intervention for the action research cycles. The platform provides an interactive environment where students collaboratively organize vocabulary, integrate visual elements, and construct contextualized sentences. This approach is expected to transform fragmented vocabulary instruction into a meaningful learning experience that enhances vocabulary mastery and student engagement (Mayer, 2021).

During the planning stage, the researcher developed two lesson plans for twelfth-grade students focusing on Argumentative Text within the theme of Digital Finance. This topic was selected because it reflects students' everyday experiences, particularly issues surrounding cash and cashless transactions, allowing vocabulary learning to occur in meaningful contexts. The lesson plans integrated Digital Mind Mapping through Miro, emphasizing students' ability to understand vocabulary form, meaning, and contextual use rather than memorizing individual words. This instructional design encouraged learners to analyze vocabulary critically while developing a broader understanding of digital finance concepts (Buzan, 2018).

The first meeting was conducted on Tuesday, November 11, 2025, with 29 students present and two students absent with permission. The lesson began with greetings, motivation, and an explanation of the learning objectives, emphasizing vocabulary form, meaning, and use. Students then analyzed an e-money text to identify its social function and generic structure before receiving guidance on using the Miro platform. The researcher also introduced affixes to strengthen students' morphological awareness. Through brainstorming and group collaboration, students identified digital finance vocabulary, analyzed each lexical item based on FMU (Form, Meaning, and Use), and organized their findings into collaborative digital mind maps that were later presented to the class (Buzan, 2018).

The second meeting took place on Thursday, November 13, 2025, with full student attendance. The lesson extended students' analytical abilities through a complete argumentative text discussing e-money. Students identified its organizational components, including the Thesis Statement, Arguments For, Arguments Against, and Reiteration. Subsequently, they continued collaborative brainstorming and vocabulary development using Miro, visually organizing new lexical items while exploring their meanings and contextual applications. The session concluded with group presentations followed by question-and-answer discussions, enabling students to justify their ideas while developing critical thinking and communicative competence (Mayer, 2021).

At the end of the lesson, the teacher facilitated a collaborative review of the material and distributed reflection sheets to evaluate students' understanding of both argumentative text structure and vocabulary. The meeting ended with positive reinforcement and a preview of the subsequent learning unit.

Observation findings demonstrated gradual improvement in students' learning behaviors and cognitive processes as they became more familiar with Digital Mind Mapping.

Initially, students relied on linear vocabulary lists with little organization, indicating limited cognitive scaffolding. However, during the second meeting they began categorizing vocabulary according to Form, Meaning, and Use (FMU), reflecting greater ability to organize linguistic information systematically despite occasional spelling errors. This transition illustrates the development of more structured vocabulary processing (Nation, 2013).

Students also showed notable progress in Radiant Thinking. During the first meeting, they hesitated to expand mind maps independently and frequently sought teacher confirmation before adding new branches. By the second meeting, they displayed greater confidence in generating associations autonomously, suggesting that they had begun internalizing associative thinking and brainstorming strategies central to mind mapping (Buzan, 2018).

Improvements were likewise observed in Dual Coding. At first, students created simple mind maps using limited shapes and colors, resulting in visually monotonous representations. As the cycle progressed, they incorporated more varied colors and visual structures to distinguish information categories. Although sophisticated imagery was still limited, this development indicates increasing awareness of visual-spatial organization to support verbal learning (Mayer, 2021).

Regarding the Affective Filter and technological literacy, many students initially experienced anxiety while learning to operate the Miro platform. Technical difficulties increased cognitive load and extended the duration of classroom activities beyond the planned schedule. Nevertheless, greater familiarity with the application during the second meeting reduced students' anxiety, enabling them to concentrate more on vocabulary learning, explore additional Miro features, and participate more confidently in collaborative activities. These findings are consistent with the concept that reduced anxiety facilitates language acquisition (Krashen, 1982).

Finally, students demonstrated stronger conceptual connectivity throughout the cycle. Early outputs consisted mainly of five or six isolated words copied directly from the source text. By the second meeting, students progressed to constructing original simple sentences using newly acquired vocabulary, indicating an emerging ability to connect lexical knowledge with meaningful language production. This progression reflects an important step toward greater communicative independence and contextual vocabulary use (Nation, 2013).

Classroom observations during Cycle 1 showed that the teacher gradually shifted from addressing technical issues toward integrating digital mind mapping into meaningful learning activities. Throughout both meetings, the teacher consistently modeled mind-mapping strategies by first demonstrating hierarchical branching and later extending the activity to vocabulary categorization based on word classes such as nouns, verbs, and adjectives. Trigger questions were also employed to activate students' prior knowledge and encourage vocabulary associations within digital finance contexts. These instructional practices align with scaffolding principles that support conceptual understanding through guided modeling (Vygotsky, 1978).

Technology integration also demonstrated noticeable improvement throughout Cycle 1. The first meeting required extensive onboarding, as much of the lesson was devoted to account registration and familiarization with Miro's interface. By the second meeting, students navigated the platform more independently, allowing the teacher to emphasize pedagogical aspects such as visual categorization through different colors for each word class. This practice strengthened dual coding by combining verbal and visual representations, thereby supporting vocabulary retention (Paivio, 1986). Despite these improvements, classroom observations indicated that students mostly worked individually within the shared workspace and rarely engaged in collaborative brainstorming. Consequently, the collaborative affordances of Miro had not yet been fully utilized, suggesting that further instructional refinement was necessary to promote real-time interaction among learners.

The overall achievement demonstrated measurable improvement but remained below the predetermined Learning Objective Achievement Criteria (KKTP) of 75.00. Only 13 students (41.94%) achieved the passing grade, while 18 students (58.06%) failed to meet the expected standard. Although the findings indicated positive learning development compared with the initial condition, they also confirmed that most students had not yet achieved satisfactory vocabulary mastery, indicating the need for a second action cycle (Kemmis et al., 2014).

A more detailed analysis showed that the Matching section recorded the lowest performance (64.5%), followed closely by Multiple Choice (65.2%). Students experienced difficulties in identifying appropriate vocabulary relationships and selecting correct lexical

items. In contrast, the Translation section obtained the highest average (72.4%), suggesting stronger ability to interpret vocabulary into meaningful expressions despite remaining below the expected mastery level.

Overall, the implementation of digital mind mapping contributed to positive vocabulary development during Cycle 1; however, the class average and the proportion of students meeting the KKTP had not yet reached the expected level. Therefore, the study proceeded to Cycle II, where instructional improvements focused on strengthening contextual understanding, grammatical awareness, and spelling accuracy to address the remaining learning gaps.

The interview findings revealed three major dimensions of students' experiences. The first, affective dimension, showed generally positive perceptions toward Miro. High- and average-achieving students reported increased enjoyment and motivation because the platform offered a more creative and engaging learning environment than conventional methods. However, low-achieving students indicated that their motivation was strongly influenced by technical issues such as slow system performance or unsaved work, demonstrating that technology reliability directly affected learning engagement (Deci & Ryan, 2000).

The second, technical dimension, highlighted usability and implementation barriers. Average- and low-achieving students frequently identified unstable internet connections, limitations of the free version, and inadequate mobile devices as the primary obstacles during learning. Even high-achieving students acknowledged that mastering Miro required considerable time before they could efficiently organize ideas within the digital workspace. These findings suggest that successful technology integration depends not only on pedagogical design but also on sufficient technological infrastructure and user familiarity (Mishra & Koehler, 2006).

Overall, the interview data indicate that digital mind mapping effectively enhanced students' motivation, organization of vocabulary, and memory retention. Nevertheless, its effectiveness varied according to students' achievement levels, with lower-achieving learners being more affected by technical limitations. These findings suggest that the successful implementation of digital mind mapping requires not only pedagogical support but also adequate technological resources and sufficient opportunities for students to develop confidence in using the platform (Mishra & Koehler, 2006).

Student interviews conducted on November 18, 2025, further supported these findings by revealing positive perceptions across affective, cognitive, and technical dimensions. Students consistently reported that the use of colors, images, and visual organization enhanced motivation and facilitated vocabulary retention. Visual mapping enabled learners to classify words more systematically, such as distinguishing nouns and verbs through color coding, demonstrating that the intervention successfully promoted meaningful vocabulary organization rather than simple memorization (Buzan, 2018). These responses confirmed that Digital Mind Mapping effectively enhanced students' motivation and cognitive processing.

However, interviews also identified several barriers that reduced the overall effectiveness of the intervention. High-achieving students adapted successfully to the application, whereas lower-achieving students remained highly dependent on stable internet access and adequate devices. Slow connections, limited features in the free version of Miro, and small smartphone screens frequently disrupted participation and reduced motivation. Even proficient students acknowledged that mastering the application required considerable time and occasionally resulted in disorganized mind maps when managing complex information. To overcome these issues, the researcher planned several improvements for Cycle 2, including simplified and offline-compatible templates, concise technical briefings at the beginning of each lesson, and pre-downloaded visual resources to reduce dependence on internet connectivity. These revisions were intended to maintain students' motivation while minimizing technical barriers and promoting more equitable learning opportunities.

Reflection on Cycle 1 also identified several major obstacles that limited vocabulary development. First, students often prioritized visual attractiveness over linguistic accuracy, producing aesthetically appealing mind maps but demonstrating limited mastery of vocabulary forms. Second, learning the Miro interface simultaneously with new financial terminology imposed excessive cognitive load, reducing the efficiency of vocabulary acquisition. Third, teacher intervention was frequently redirected toward technical assistance rather than providing comprehensive corrective feedback on FMU, limiting opportunities for linguistic refinement. Fourth, the collaborative potential of the shared digital workspace was not fully realized because students completed tasks individually instead of engaging in

structured peer interaction. Fifth, unequal access to reliable internet connections and suitable devices disproportionately affected lower-achieving students, making their motivation vulnerable to technical problems. Finally, the time allocated for technical orientation reduced opportunities for vocabulary drilling and active recall, creating a mismatch between the planned instructional schedule and actual classroom implementation.

Based on these reflections, the researcher redesigned the instructional procedures for Cycle 2 to address the identified weaknesses. The revised plan introduced Miro's pre-structured templates containing designated sections for Form, Meaning, and Use (FMU), allowing students to focus directly on vocabulary classification instead of designing mind maps from scratch. Additional linguistic scaffolding was incorporated through intensive active-recall exercises and contextual vocabulary practice to strengthen lexical retention. Structured peer-feedback sessions were also implemented, requiring each group to review and discuss another group's work, thereby promoting collaborative learning and collective error correction in accordance with social constructivist principles (Vygotsky, 1978).

The planning stage of Cycle 2 emphasized implementing the revisions identified after Cycle 1 by redirecting instruction from software operation toward vocabulary accuracy. A revised lesson plan was prepared to prioritize linguistic development rather than technical navigation. To minimize technical obstacles, the researcher designed pre-structured Miro templates containing dedicated Form, Meaning, and Use (FMU) sections, enabling students to focus directly on vocabulary organization. Additional learning resources included offline Asset Bundles consisting of relevant images and icons, together with a simplified Technical Shortcut Guide to support students encountering technical difficulties. Collaborative learning was also strengthened through structured peer-feedback activities and scheduled linguistic monitoring sessions. These preparations were intended to promote a social constructivist learning environment in which active recall, peer interaction, and collaborative error correction supported vocabulary acquisition (Vygotsky, 1978).

During the first meeting (20 November 2025), the lesson began with a brief technical orientation lasting less than ten minutes. Students received a technical shortcut guide and learned to use the pre-designed Miro templates, reducing software-related anxiety and allowing greater attention to vocabulary learning. Throughout the main activity, students collaboratively completed the FMU sections using the prepared visual materials, while the researcher monitored spelling accuracy and vocabulary classification through continuous checkpoints. The lesson concluded with active recall exercises and sentence-construction tasks to reinforce vocabulary retention and prepare students for the following session.

The second meeting (25 November 2025) concentrated on consolidating vocabulary knowledge through collaboration. After reviewing the structure of Hortatory Exposition texts and discussing the importance of precise vocabulary, students participated in mandatory peer-feedback by evaluating neighboring groups' digital mind maps for spelling and FMU accuracy. Each group subsequently revised its work before presenting and defending its vocabulary choices to the class. The session ended with teacher feedback highlighting improvements in vocabulary accuracy, recognition of effective collaboration, and preparation for the Cycle 2 posttest. These instructional activities reflected principles of collaborative learning, scaffolding, and active retrieval practice that facilitate deeper vocabulary acquisition (Vygotsky, 1978).

Observation findings demonstrated substantial improvements across five developmental dimensions. First, cognitive scaffolding progressed from simple vocabulary organization toward more refined linguistic categorization. The structured Miro templates enabled students to classify vocabulary efficiently into Form, Meaning, and Use (FMU), and by the second meeting they were able to organize increasingly complex vocabulary with greater logical consistency.

Second, radiant thinking developed considerably as students established faster lexical connections. The shortened technical briefing allowed immediate engagement with vocabulary mapping, while active recall activities encouraged students to identify synonyms and semantic relationships more spontaneously, indicating the development of richer lexical networks.

Third, dual coding became more effective through the purposeful integration of visual elements. Rather than selecting decorative images, students matched vocabulary with meaningful icons that later served as memory cues for recalling spelling and meaning, supporting the principles of visual-verbal integration (Paivio, 1986).

Fourth, students' affective filter decreased noticeably. Reduced technical complexity created a more relaxed classroom atmosphere, encouraging students to experiment with

unfamiliar vocabulary and participate confidently in peer-feedback without excessive fear of making mistakes (Krashen, 1982).

Finally, conceptual connectivity advanced from identifying vocabulary relationships to applying words accurately in complete sentences. Students demonstrated the ability to transfer knowledge from digital mind maps into contextual sentence production, indicating successful vocabulary internalization. Overall, the observations suggest that minimizing technical barriers enabled students to maximize the pedagogical benefits of digital mind mapping for vocabulary learning.

By the second meeting, these weaknesses had largely been resolved. The teacher guided students to select meaningful visual representations and challenged them to justify vocabulary organization, synonym selection, and contextual usage. Students also demonstrated greater autonomy during peer-feedback activities while maintaining technical accuracy within the Miro environment. Overall, Cycle 2 reflected a successful transition from technical adaptation toward a balanced integration of pedagogy and technology. The use of structured templates and targeted FMU scaffolding reduced cognitive load, promoted collaboration, and supported more independent vocabulary learning (Sweller, 1988).

Performance across the three assessment components was consistently positive. Students obtained an average of 7.48 in multiple-choice items assessing vocabulary form, 7.45 in matching items evaluating vocabulary meaning, and 16.13 in translation tasks measuring contextual vocabulary use. Although a few multiple-choice items remained challenging, the matching section showed considerable improvement, suggesting that previous confusion regarding polysemous vocabulary had largely diminished. Translation remained the strongest component, demonstrating students' ability to apply vocabulary accurately in complete sentences.

These improvements indicate that Digital Mind Mapping through Miro effectively strengthened vocabulary learning in three interconnected dimensions. First, organizing vocabulary visually enhanced recognition of spelling patterns and morphological structures. Second, contextual grouping reduced confusion regarding multiple meanings by connecting words with related concepts and images. Third, hierarchical visual organization improved syntactic awareness, enabling students to construct accurate sentences using digital finance terminology. Consequently, the researcher concluded that the instructional objectives of Cycle 2 had been successfully achieved (Paivio, 1986).

Interviews were conducted on 27 November 2025 with six students representing high, intermediate-, and low-achieving groups. Overall, students reported positive experiences while acknowledging several remaining technical challenges.

Regarding the affective dimension, high-achieving students emphasized that the visual organization of Digital Mind Mapping improved both motivation and confidence. Intermediate students viewed the digital environment as enjoyable and engaging, whereas lower-achieving students appreciated the simplified learning process, which reduced anxiety and encouraged continued English learning.

From the technical perspective, most students reported becoming increasingly familiar with the Miro application after repeated practice. High-achieving students focused on optimizing branch organization and keyword selection, while intermediate students explained that initial confusion disappeared as they became accustomed to the interface. Some lower-achieving students experienced device-related problems, including application glitches; however, they generally perceived Miro as easy to understand once technical issues were resolved.

The cognitive dimension revealed that Digital Mind Mapping facilitated deeper vocabulary processing through visualization. High-achieving students used branch structures to analyze spelling, affixes, and semantic relationships critically. Intermediate students relied on colors and branch organization as mnemonic strategies, while lower-achieving students highlighted that visual customization through colors and images made vocabulary easier to understand and remember. Collectively, these findings suggest that students benefited from the combination of visual organization, repeated practice, peer collaboration, and structured teacher guidance rather than from the digital application alone (Vygotsky, 1978).

Reflection on Cycle 2 indicated that simplifying technical demands substantially improved the implementation of the instructional action. The class achieved a mean posttest score of 77.66, with 77.42% of students meeting the KKTP. Students also devoted considerably more classroom time to discussing vocabulary form, meaning, contextual usage, and sentence construction instead of learning software operations.

Interview findings reinforced these observations. High-achieving students valued the analytical support provided by mind mapping, intermediate students emphasized the usefulness of visual cues for memory, and lower-achieving students appreciated the simplified learning process despite experiencing occasional technical limitations. These findings indicate that successful vocabulary development depended on appropriate scaffolding, collaborative learning, and adequate technological access rather than solely on the use of Miro.

Based on the combined evidence from observations, interviews, and descriptive test results, the predetermined classroom success criteria were achieved. Consequently, the researcher concluded the classroom action research after Cycle 2 while acknowledging that continuous instructional refinement remains necessary to address remaining differences in learner independence and technology access (Hake, 1999).

Discussion

The implementation of Classroom Action Research demonstrated that the integration of Digital Mind Mapping through the Miro application effectively enhanced students' vocabulary acquisition by combining technological support, pedagogical strategies, and psychological scaffolding. The quantitative findings, reflected in a posttest mean score of 77.66 and an N-Gain score of 0.61, indicate that the intervention successfully improved students' vocabulary mastery. These findings are consistent with Nation (2013), who argues that complete lexical knowledge requires mastery of form, meaning, and use, both receptively and productively.

Regarding mastery of form, students achieved an average score of 74.8% in the Multiple Choice section, indicating substantial improvement in recognizing spelling, pronunciation, and morphological patterns. This outcome can be explained by Paivio's Dual Coding Theory (1991), which emphasizes that learning becomes more effective when verbal and visual information are processed simultaneously. Through Miro, students combined written vocabulary with visual representations, enabling stronger memory retention of word structures. This result is consistent with the findings of Kim and Hartono (2024), who reported that digital mind mapping produces better vocabulary recall than conventional note-taking by strengthening visual and textual associations.

For mastery of meaning, students obtained an average score of 74.5% in the Matching section, showing improved understanding of vocabulary within contextual categories. Organizing lexical items into thematic branches reduced confusion, particularly with polysemous words, by connecting vocabulary to meaningful contexts. This finding supports Sweller's Cognitive Load Theory (1994), which explains that structured information reduces cognitive overload, and aligns with Buzan (2006), who proposes that mind mapping reflects the brain's natural associative thinking process. Consequently, contextual organization through digital mind maps facilitated deeper semantic understanding and strengthened students' lexical networks.

The highest achievement appeared in mastery of use, where students reached an average score of 80.65% in the Translation section. This indicates that Digital Mind Mapping effectively supported the transition from passive vocabulary recognition to active language production. The infinite canvas provided by Miro enabled students to visualize grammatical relationships, lexical hierarchies, and contextual usage, thereby improving syntactic awareness and practical vocabulary application. These findings are consistent with Zhang and Choi (2023), who concluded that Miro enhances vocabulary learning by allowing learners to create meaningful lexical connections and personalize their learning process.

The qualitative findings further revealed that the use of Miro transformed the classroom environment by promoting active participation while reducing learning anxiety. The integration of digital tools with structured teacher guidance created a supportive atmosphere in which students became more willing to engage in vocabulary activities. This indicates that technological innovation contributes not only to cognitive development but also to positive classroom interaction.

In terms of active engagement and motivation, interview data showed that students with different proficiency levels benefited from Miro in distinct ways. High-achieving students appreciated its structured organization, whereas intermediate learners were motivated by its interactive features. These findings support Vygotsky's Sociocultural Theory (1978), which emphasizes that learning develops through social interaction, collaboration, and guided support. Collaborative activities and peer feedback within Miro encouraged students to construct knowledge collectively while increasing motivation to participate in English learning.

The findings also demonstrate a reduction in students' affective filter. Consistent with Krashen's Affective Filter Hypothesis (1982), lowering anxiety created more favorable conditions for language acquisition. Initial concerns related to unfamiliarity with the software were minimized through pre-designed Miro templates and concise technical guidance. As students became more confident with the platform, they showed greater willingness to experiment with new vocabulary, participate in discussions, and accept peer corrections without fear of making mistakes. These results are further supported by Khan et al. (2025), who found that Miro increases learner engagement, satisfaction, autonomy, and sustained interaction with the target language.

5. Conclusion

The findings of this study lead to two main conclusions. First, students' vocabulary achievement showed consistent improvement throughout the implementation of the two action research cycles. The average score increased from 42.26 in the pre-test to 68.63 after Cycle 1 and reached 77.66 after Cycle 2. In addition, 77.42% of the students achieved the KKTP. These findings indicate a positive improvement in the vocabulary performance of Class XII B. However, the results should be interpreted within the context of the participating class and cannot be generalized to other classes or considered evidence that Miro-based digital mind mapping alone was solely responsible for the observed improvement.

Second, the qualitative findings suggest that the most meaningful development was the shift from passive reliance on translation to a more active process of organizing and applying vocabulary knowledge. Students gradually learned to connect spelling, meaning, affixes, and example sentences by using branches, colors, and images in their mind maps. They also became more willing to explain their ideas to classmates and participated with greater confidence during classroom activities. This progress emerged gradually rather than immediately. During Cycle 1, several challenges were identified, including unfamiliarity with the platform, differences in digital literacy, unstable internet connections, and limited access to suitable devices. These issues highlighted that the effectiveness of the digital tool depended on appropriate instructional support, including structured templates, concise technical guidance, peer collaboration, and repeated reflective activities. Although classroom observations indicated that many students became less anxious over time, this aspect was not assessed using a standardized affective instrument, and several students continued to require additional support.

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