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The Impact of Teaching through the Concept Mapping Strategy on the Educational Achievement of Sixth Graders in Sciences

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Abstract

This research set out to see how using the Concept Mapping Strategy affected sixth-grade students' interest and success in science at an Arab elementary school in northern Israel. The study combined both numbers and personal experiences, using a quasi-experimental approach with tests taken before and after to analyze results, along with conversations, teacher notes, and student feedback. 240 students took part, split into two groups: one group used concept mapping, while the other learned in a more traditional way. The results showed the concept mapping group made clear gains in both test scores and interest levels, showing concept mapping's role in boosting science learning. Students in this group not only engaged more but also showed better grasp of ideas, stronger organizational and analytical skills, and felt more confident in their abilities. Although some students initially struggled to get the hang of the technique and felt pressured by the time it took, many found it useful and even helpful for other subjects. The study wraps up by noting that concept mapping is a practical teaching method that helps with engagement, understanding, and critical thinking skills in science classes.

Keywords

Concept Mapping, Science Learning, Student Interest, Academic Progress, Mixed Methods, Primary School

1. Introduction

Lately, there's been a big push for teaching methods that get students more actively involved and really understanding the material, and concept mapping has popped up as a pretty unique tool for this (Bizimana et al., 2022a; Bizimana et al., 2022b). Concept mapping, where you organize information visually to show how ideas link together, is used in many areas to encourage meaningful learning (Lin et al., 2024; Liu et al., 2023b; Rasyid, 2023). This approach pushes students to engage with the material in a way that moves beyond just memorizing facts, aiming for a richer understanding (Chen et al., 2024b; Choudhary & Bano, 2022). In science education, where it's often tough to grasp how things connect, concept mapping has shown potential in boosting both understanding and memory (Hwang et al., 2022; Hwang et al., 2023). By helping students visualize knowledge, concept mapping makes it easier for them to link concepts, spot patterns, and organize what they've learned in science in a way that might improve their school performance (Chen et al., 2024a; Choudhary & Bano, 2022; Huang et al., 2024; Lin et al., 2024).

The idea behind using concept mapping in science classes comes from the need to make the subject more approachable and understandable for students. Science can feel tough, especially for younger kids who may find it hard to wrap their heads around the abstract parts (Bizimana et al., 2022e; Bizimana et al., 2024). Old-school teaching methods don't always help these challenges, sometimes leaving students with gaps in what they know and lower grades (Khairani & Aloysius, 2023; Kpiranyam et al., 2024). Concept mapping shakes things up by setting up information in a way that lets students see how ideas are connected, helping them understand better and making learning feel more hands-on (Anastasiou et al., 2024; Bizimana et al., 2022c; Chen et al., 2024b). This fits well with the mental growth happening in sixth graders, who are starting to think in more complex ways and can gain from strategies that build on those developing skills (Bizimana & Sibomana, 2024; Kpiranyam et al., 2024; Sercenia & Prudente, 2023; Yadav & Chaurasia, 2024).

This study matters because it could help make science education better in northern Israel's Arab community. Science is a key subject that sets the stage for students' academic and career paths, so having teaching methods that work is crucial for giving students a solid foundation. Concept mapping, by deepening students' understanding of science, might also help them feel more confident and perform better in school. Focusing on sixth graders means the study tackles an important period in students' lives, right when they're moving into more challenging learning and need tools that support their growth in scientific thinking.

Research on concept mapping has shown it positively affects different areas of learning (Nakum, 2022; Namangolwa & Peter, 2024). Studies report that students using this method often show stronger critical thinking, improved memory, and a better handle on complicated subjects (Chen et al., 2024b; Hwang et al., 2023; Liu et al., 2023a; Orluwene & Amadioha, 2024). The research also highlights how concept mapping is a great match for science learning, fitting well with how students absorb scientific ideas and theories (Anastasiou et al., 2024; Rasyid, 2023; Bizimana et al., 2024; Akhtar & Saeed, 2022). Yet, while there's a good amount of work backing up concept mapping in general education, fewer studies focus directly on how it affects science skills in younger students, especially in communities that don't always get a lot of research attention (Akhtar & Saeed, 2022; Anastasiou et al., 2024; Bizimana et al., 2022b; Muvid et al., 2023).

Despite existing research (Ayimbila et al., 2023; Hwang et al., 2022; Khairani & Aloysius, 2023; Mohammadpour & Maleki, 2024), there's still a gap in knowing exactly how concept mapping works for sixth graders in Arab communities. Past studies often look at older students or wider samples, missing the chance to see how this method could specifically support science learning in particular cultural or regional backgrounds. This study steps in to fill that gap by examining the impact of concept mapping on science achievement in northern Israel's Arab community, a group not frequently spotlighted in educational research. Doing so may offer fresh findings that help shape teaching techniques for this unique set of students.

This research broadens what we know about concept mapping as a learning tool within a specific cultural setting. Practically, it hopes to bring evidence-backed suggestions for teachers wanting to improve science outcomes for their students. By highlighting how concept mapping could benefit students, the study might inspire educators to try it in their classes, aiming for better academic results and a more hands-on learning environment. Plus, it could lay the groundwork for more studies into how concept mapping could be adapted in different places and cultures.

The goal here is to see if teaching science through concept mapping actually boosts sixth graders' grades in northern Israel's Arab community. Using an experimental approach with groups for comparison, the study seeks to find out if this method can give students an edge in science, providing useful takeaways on what works best for this age and community in learning science.

2. Theoretical Framework

This study's theoretical framework pulls from constructivist theories that stress the active role students take in building their own understanding. Concept mapping fits well with constructivist ideas, as it encourages students to dive into the material themselves, organizing and linking concepts to make sense of them (Bizimana et al., 2022a; Bizimana et al., 2022b). According to these theories, learning works best when students interact with content in ways that feel personal and relevant, allowing them to connect new ideas to what they already know (Lin et al., 2024; Liu et al., 2023b; Rasyid, 2023). This approach is quite different from traditional rote learning, which often doesn't help students relate one idea to another (Chen et al., 2024b; Choudhary & Bano, 2022).

Ausubel's Theory of Meaningful Learning also backs the use of concept mapping, stressing the importance of linking new information to existing mental structures (Hwang et al., 2022; Hwang et al., 2023). In this model, learning deepens when students can arrange and connect new information, creating cognitive ties that enhance understanding (Chen et al., 2024a; Choudhary & Bano, 2022; Huang et al., 2024; Lin et al., 2024). Concept maps offer a visual of these connections, helping students handle information and improve memory (Laar et al., 2024; Lin et al., 2024).

Vygotsky's Social Constructivism focuses on social interaction in learning, showing how collaboration and support affect the process (Nayak & Rout, 2022; Orluwene & Amadioha, 2024). Concept mapping can also be done as a group activity, giving students a chance to work together on maps, which builds shared understanding (Awudi & Danso, 2023; Chen et al., 2024a; Hwang et al., 2024). Through peer learning and shared ideas, students can strengthen their grasp of science concepts (Jack, 2023; Laar et al., 2024; Nayak & Rout, 2022; Varoğlu et al., 2024).

Cognitive Load Theory also explains why concept mapping works well, as it eases cognitive load by visually arranging information (Bizimana et al., 2022a; Bizimana et al., 2022b). By breaking complex ideas into simpler, linked parts, concept mapping helps students manage and understand information more easily (Lin et al., 2024; Liu et al., 2023b; Rasyid, 2023). This visual layout cuts down on unnecessary cognitive load, freeing up mental space for deeper comprehension (Chen et al., 2024b; Choudhary & Bano, 2022).

3. Review of Related Studies

The Role of Concept Mapping in Science Education

Concept mapping has become a helpful tool in science education, offering students a way to visually organize and display knowledge in a structured layout. This method allows learners to spot connections between ideas, supporting a richer grasp of science topics (Awudi & Danso, 2023; Ayimbila et al., 2023). Research has shown that concept mapping can improve how well students remember complex scientific details by encouraging them to engage actively with the material rather than merely memorizing it (Bizimana et al., 2022e; Bizimana et al., 2024). As students build maps linking different ideas, they learn to place scientific concepts within larger frames of understanding, which boosts their comprehension (Bizimana et al., 2022a; Bizimana et al., 2022d; Bizimana et al., 2022e; Lin et al., 2024).

One key benefit of concept mapping in science education is how well it fits with constructivist theories, where students construct knowledge through exploration and reflection on their learning (Khairani & Aloysius, 2023; Kpiranyam et al., 2024). Making these maps pushes students to critically examine and fine-tune their knowledge, moving beyond surface learning to gain deeper understanding (Rasyid, 2023; Reshma, 2023). By showing the links between ideas visually, students are encouraged to explore how scientific ideas connect, which is a vital skill for tackling complex subjects (Akintola & Odewumi, 2023; Awudi & Danso, 2023; Bizimana et al., 2024; Chang & Yang, 2023).

Concept mapping also helps to lessen the mental load by arranging information in an easy-to-follow way, which is particularly useful in science classes where there's often a lot of dense content (Alt et al., 2023; Awudi & Danso, 2023). This visual setup assists students in handling vast amounts of information, making it easier for them to focus on understanding rather than feeling overwhelmed by too much data (Chang & Yang, 2023; Hwang et al., 2022; Khairani & Aloysius, 2023). Additionally, research suggests that concept mapping boosts problem-solving skills by allowing students to break down tough questions into simpler parts and pinpoint meaningful connections (Nakum, 2022; Sercenia & Prudente, 2023; Yadav & Chaurasia, 2024).

Constructivist Approaches to Learning and Conceptual Understanding

Constructivist approaches to learning highlight the idea that learners build knowledge themselves, rather than simply absorbing information from outside sources. In this view, new ideas get combined with what learners already know, making learning a personal and fluid experience (Alt et al., 2023; Anastasiou et al., 2024). This method pushes students to get hands-on, asking questions, exploring, and solving problems to better understand and remember what they're learning (Chang & Yang, 2023; Chen et al., 2024a). Constructivism suits science education well, encouraging students to apply critical thinking and see how different ideas connect, which is especially helpful for mastering complex scientific topics (Anastasiou et al., 2024; Bizimana et al., 2022c; Chen et al., 2024b).

In a constructivist classroom, the teacher acts more as a guide than a source of answers. This setup lets students take charge of their learning, giving them a sense of independence and responsibility (Jack, 2023; Kar, 2022). Constructivism also thrives in a collaborative setting, where students can discuss ideas and tackle problems together, helping both their social and thinking skills grow (Bizimana & Sibomana, 2024; Kpiranyam et al., 2024; Sercenia & Prudente, 2023; Yadav & Chaurasia, 2024). This kind of classroom doesn't just build personal understanding; it also encourages students to value different perspectives, broadening their grasp of concepts (Nakum, 2022; Namangolwa & Peter, 2024).

One big idea in constructivist theory is that learning sticks better when it feels relevant. By tying new knowledge to real-life examples or what students already know, they're more likely to remember and use what they learn in real situations (Chen et al., 2024a; Bizimana & Sibomana, 2024). This is different from traditional rote learning, where students might memorize facts without fully getting their meaning or use, often leading to poor long-term memory (Muvid et al., 2023; Nayak & Rout, 2022; Varoğlu et al., 2024). In science classes, constructivist methods let students dive into ideas in ways that spark their curiosity, making them want to ask questions and search for answers (Chen et al., 2024b; Hwang et al., 2023; Liu et al., 2023a; Orluwene & Amadioha, 2024).

Cognitive Theories Underpinning Concept Mapping Strategies

Cognitive theories give us a look at why concept mapping can work so well for learning, especially in organizing and managing information. A key cognitive idea behind concept mapping is Cognitive Load Theory, which says learning is easier when mental effort is balanced right (Akhtar & Saeed, 2022; Akintola & Odewumi, 2023). Concept mapping cuts down unnecessary mental strain by laying out information visually and clearly, helping students concentrate on the main points of a topic (Huang et al., 2024; Hwang et al., 2024). By arranging information in a spatial way, concept maps make it easier for students to hold onto and recall knowledge, reducing the mental work needed to grasp complex ideas (Anastasiou et al., 2024; Rasyid, 2023; Bizimana et al., 2024; Akhtar & Saeed, 2022).

Schema Theory also relates closely to concept mapping. Schemas are mental structures that help us sort and make sense of information, and concept mapping directly encourages the growth of these structures by allowing students to connect ideas visually (Mohammadpour & Maleki, 2024; Muvid et al., 2023). This visual structure matches how the mind organizes details, making it simpler to remember and use in problem-solving (Laar et al., 2024; Bizimana & Sibomana, 2024; Orluwene & Amadioha, 2024). As students make concept maps, they actively shape and adjust their schemas, which builds a deeper understanding and helps them remember what they've learned long-term (Yadav & Chaurasia, 2024; Akhtar & Saeed, 2022).

The Dual Coding Theory also supports concept mapping, suggesting that information sticks better when it's presented both visually and verbally. Concept maps combine these two formats, allowing students to grasp science ideas through images and words, which strengthens learning (Ayimbila et al., 2023; Liu et al., 2023a). Research shows that mixing visual and verbal elements, as done in concept mapping, boosts understanding and memory, especially in subjects that link multiple ideas, like science (Kar, 2022; Laar et al., 2024; Mohammadpour & Maleki, 2024). This two-way presentation in concept maps helps create stronger connections and lightens mental effort, supporting better learning and recall (Alt et al., 2023; Kar, 2022; Nakum, 2022; Reshma, 2023).

Impact of Teaching Strategies on Educational Achievement in Elementary School Science

Good teaching methods play a big role in helping young students succeed in elementary science, where they're just starting to learn the basics of science concepts and ideas. Research shows that interactive and question-driven teaching approaches can really help students understand and stay interested in science topics (Bizimana et al., 2022c; Bizimana et al., 2022d). Using activities like hands-on experiments and group work gets students involved in learning, which builds their critical thinking and problem-solving abilities (Liu et al., 2023a; Liu et al., 2023b). These strategies not only boost understanding but also make science more appealing by connecting it to things students find engaging (Akhtar & Saeed, 2022; Anastasiou et al., 2024; Bizimana et al., 2022b; Muvid et al., 2023).

On top of that, using different teaching styles helps meet the various learning needs in elementary science classes. Differentiated instruction allows teachers to adjust lessons to fit each student's pace and way of learning. Giving students several ways to grasp ideas can help close the gaps in achievement and encourage every student to do well (Sercenia & Prudente, 2023; Varoğlu et al., 2024). Studies have found that when teachers bring in a mix of methods—like visuals, group discussions, and individual feedback—students tend to perform better (Lin et al., 2024; Jack, 2023). This is especially useful in elementary classes, where students benefit from lessons that meet them at their own level (Sercenia & Prudente, 2023; Rasyid, 2023).

Bringing technology into teaching is also proving to help boost students' science performance by offering fun, interactive ways to learn. Tools like digital simulations and learning software let students dive into science concepts in ways that go beyond regular classroom limits, making tough ideas feel more concrete (Ayimbila et al., 2023; Hwang et al., 2022; Khairani & Aloysius, 2023; Mohammadpour & Maleki, 2024). Technology also supports tailored learning, with resources that adapt to each student's skill level, improving understanding and memory of science topics (Akhtar & Saeed, 2022; Alt et al., 2023; Ayimbila et al., 2023).

Another effective method is project-based learning, which has become a popular approach to raising science performance in elementary schools. This technique lets students dig into science questions over longer periods, encouraging them to put their knowledge into real-life use (Hwang et al., 2023; Reshma, 2023; Jack, 2023). Project-based learning promotes teamwork, independent thinking, and problem-solving—all important skills in science—and gives students a chance to deepen their understanding of science ideas through hands-on projects that connect with the real world (Bizimana et al., 2022c; Bizimana et al., 2022d).

4. Methods

4.1. Research Design

This study uses a mix of methods with both pre- and post-testing to check if the Concept Mapping Strategy boosts sixth graders' learning in science. The mixed approach combines number-focused analysis with descriptive feedback to gauge how students' knowledge and experience are affected. By blending academic performance data with notes on how students feel and act while learning, the study aims to capture a fuller view of how well this teaching method works.

In the quantitative part, the study follows a pre- and post-test design to see if concept mapping helps these sixth graders improve in science. Two classes at an Arab elementary school in northern Israel took part, split into an experimental group and a control group, each with 120 students. The experimental group used concept maps in their lessons, while the control group kept to standard methods. To set a starting point, both groups took a test at the beginning to show what they already knew. Then, after six months, they took the same test again to see if there were any changes in science scores. Students in the experimental group also created concept maps that were evaluated for how well-organized, accurate, and connected they were, giving a clearer look at their understanding and ability to link ideas in science.

For the qualitative part, the study looked at both students' and the teacher's thoughts on using the Concept Mapping Strategy, aiming to understand how engaged they felt and how they experienced this new approach. During the six months, the teacher filled out an observation checklist to track how well students were participating, working together, and staying focused during mapping activities—catching their learning engagement in the moment. After the study wrapped up, semi-structured interviews were held with some students from the experimental group to hear about their challenges and what they thought they gained from using concept maps. The teacher also shared feedback on how she saw students improve and respond overall to the strategy. Observations, interviews, and teacher feedback were sorted into themes, providing a closer look at how concept mapping shaped students' attitudes toward science and how well it helped them grasp the material.

4.2. Participants

The participants of this study consist of 240 sixth-grade students from two elementary schools in the Arab society in northern Israel, selected to form two groups of 120 students each. These students were chosen to represent a typical sample of their grade level, ensuring that the findings are applicable to the broader student population of similar educational settings. The participants include both male and female students, aged 11 to 12 years, representing the average age range for sixth graders. Importantly, all participants are typically developing students without identified special educational needs or learning disabilities, ensuring that the results reflect outcomes in a standard educational context.

The sampling method used in this study is convenience sampling, which was chosen to facilitate accessibility to the participant pool within a single school. This school was selected for its demographic alignment with the study's target population—students from the Arab society in northern Israel. The participants were drawn from two naturally occurring sixth-grade classrooms within the school. One class was designated as the experimental group, which received the Concept Mapping Strategy intervention, while the other served as the control group, continuing with traditional science instruction methods.

By utilizing convenience sampling within this school, the study could efficiently assemble a representative sample of students within the target demographic. This method also enabled the researchers to conduct the study within the natural classroom environment, thus supporting ecological validity by reflecting the students' typical learning conditions. This approach aims to provide relevant insights into how the Concept Mapping Strategy might impact educational achievement in similar classroom settings and student populations in the broader Arab society in northern Israel.

4.3. Educational Initiative Description

In this study, the focus was on using the Concept Mapping Strategy as a teaching tool to boost how well sixth graders understand science. The approach was tailored to help students dig deeper into science concepts by organizing and connecting ideas visually, moving beyond simple memorization and the usual lectureheavy methods. This way, students could engage directly with the material, forming meaningful links between scientific ideas on their own.

The Concept Mapping Strategy became a core part of the science lessons for a few months in the experimental group. Each lesson introduced a key science topic, like ecosystems, energy, or properties of matter. The teacher started by outlining the topic, highlighting essential terms and concepts that students needed to grasp. After this introduction, students received materials for creating concept maps, such as large sheets of paper, markers, sticky notes, or digital tools for those comfortable with mapping software, giving them options for map-building.

Each class followed a guided process for concept mapping. Students began by picking the lesson's main idea and placing it in the map's center. Then, they worked alone or in pairs to identify related ideas and connected these with lines, arrows, or other links. The teacher stepped in when necessary to prompt students to think through these relationships critically, pushing them to reflect on how each idea tied back to the central topic. As they filled out their maps, students were encouraged to express how ideas connected, building both understanding and communication skills.

To keep students interested, the teacher included small group discussions where students could compare and discuss their concept maps. This teamwork let them see how their classmates organized ideas and connections, deepening their grasp of the material. The teacher guided these discussions, prompting students to clarify their thoughts and revise their maps using feedback from peers.

Beyond single lessons, concept maps served as a cumulative tool that let students build on what they'd learned over time. They revisited and expanded their maps as they encountered new topics, linking earlier concepts with new ideas. For instance, while learning about ecosystems, students might start with basics like producers and consumers. Later, when exploring energy flow, they would return to their original map, adding elements that showed how energy cycles through an ecosystem. This layering helped solidify key ideas over time, aiding long-term memory.

The control group, meanwhile, followed traditional science lessons, mainly featuring teacher-led talks, textbook reading, and standard classwork. Unlike the experimental group, these students didn't use concept mapping, relying instead on conventional ways to study and understand scientific information.

During this period, the teacher in the experimental group took on a supportive but hands-off role, giving students room to shape their understanding through their concept maps. The teacher checked students' maps casually to give helpful feedback but kept the focus on letting students lead their learning and exploration. This strategy aimed to make students more active in their own education, shifting them from passive listeners to engaged knowledge-builders.

This educational effort was crafted not just to deepen students' grasp of science but to sharpen their critical thinking and organization skills. By adding concept mapping to their lessons, this initiative aimed to equip students with techniques they could use in other subjects, encouraging a more independent, involved way of learning.

To provide a comprehensive understanding of the specific concept mapping techniques used in this study, a structured approach was adopted that emphasized the explicit teaching of mapping procedures and their seamless integration with the science curriculum. A key component of this approach was the introduction of hierarchical concept mapping where students identified a central scientific concept—such as energy flow or ecological interdependence—and then arranged subordinate ideas in a tree-like structure that reflected their importance and logical relationships. The teacher provided detailed, step-by-step guidance through illustrative examples and demonstrated how complex scientific phenomena could be deconstructed into smaller, interconnected elements that students then visually represented using both traditional media and digital mapping tools.

The curriculum also incorporated the use of spider or radial maps which placed a core concept at the center with related ideas radiating outward. This method enabled students to appreciate the multidimensional relationships present in topics such as matter, energy, and ecological interactions. The mapping techniques were introduced during dedicated instructional sessions that combined teacher-led demonstrations with extensive hands-on practice. This approach allowed students to immediately apply the techniques to new content as it was presented within each science lesson.

The design included iterative mapping exercises in which students revisited and expanded their initial concept maps as the course progressed. This reinforced their understanding of cumulative scientific concepts and fostered long-term retention of information. Scaffolded activities began with highly structured mapping templates and gradually shifted toward more open-ended, student-directed map creation to accommodate diverse learning styles and varying levels of prior knowledge. Reflective discussions were integrated into each session to encourage students to articulate the rationale behind their organizational choices and critically assess the effectiveness of different mapping formats for representing complex scientific relationships.

In addition to technical instruction, the integration strategy underscored the real-world relevance of concept mapping by linking classroom activities to authentic scientific inquiry such as environmental conservation and energy management. When exploring ecosystems, students used concept maps to illustrate the intricate interplay between living organisms and their environments. The teacher facilitated guided brainstorming activities during which raw ideas were systematically refined into coherent maps through collaborative discussion and iterative feedback. Technology-enhanced tools, such as interactive digital mapping software, were introduced to allow dynamic and flexible map creation. These tools enabled students to modify and update their representations as new concepts emerged.

The combination of traditional and digital mapping practices provided a multimodal learning experience that catered to diverse student preferences while reinforcing the connection between theoretical concepts and practical applications. The curriculum was carefully aligned so that each major science topic was accompanied by a specific mapping exercise tailored to its content. Detailed rubrics outlined clear criteria for effective concept maps by emphasizing clarity of hierarchy, accuracy of connections, and creativity in linking interdisciplinary ideas. These rubrics served as both formative assessment tools and guides for student self-evaluation. The deliberate integration of diverse concept mapping techniques into the science curriculum provided students with a robust framework for organizing complex information, cultivating critical analytical skills, and linking theoretical knowledge to real-world scientific contexts.

5. Instruments

In this study, several methods were used to carefully measure the effects of the Concept Mapping Strategy on how well sixth graders grasp science concepts. Each method was chosen to pinpoint specific aspects of learning, giving a full view of the intervention's impact.

1) Pre-Test and Post-Test Assessment

The main way to track learning gains was through pre- and post-tests given to both the experimental and control groups. These tests aimed to check students' grasp and memory of science topics like ecosystems, energy, and the properties of matter. The tests had multiple-choice questions, short answers, and diagrams to cover everything from basic recall to more complex understanding.

The questions were based on science curriculum standards set by the Ministry of Education, ensuring they matched the learning goals for sixth-grade science in northern Israel. The pre-test showed each student's starting point, while the post-test revealed any growth in understanding after the study period.

2) Concept Mapping Evaluation Rubric

To fairly assess the concept maps made by the experimental group, an Evaluation Rubric was used. Adapted from Novak and Gowin's (1984) guidelines, this rubric measured elements like structure, accuracy, connection quality, and cross-links. It evaluated maps on a few specific points:

Hierarchy and Organization: Judging the map's layout and logical flow.

Accuracy and Relevance: Checking that each concept was relevant and correctly labeled.

Link Quality: Looking at how concepts were connected and if those connections reflected accurate science ideas.

Use of Cross-Links: Noting if students linked ideas across different sections, showing a stronger grasp of interconnected concepts.

Each part was scored from 1 (low) to 5 (high), allowing a close look at how students organized and linked science information.

3) Student Engagement Questionnaire

To understand how students felt about concept mapping, they filled out a Student Engagement Questionnaire at the end of the study period. Based on Appleton et al.'s (2006) Student Engagement Instrument, it covered questions about their interest in science, the usefulness of concept maps, and their motivation. Sample statements included, "I feel more interested in science when I see how ideas link together," and "Using concept maps helps me get science better."

Responses were rated on a 1 to 5 scale, capturing how students viewed and felt about concept mapping in their learning.

4) Teacher Observation Checklist

Throughout the study, teachers used an Observation Checklist to record student engagement during concept mapping. This checklist tracked behaviors like focus, teamwork, enthusiasm, and time spent on tasks. Based on Schlechty's (2002) Classroom Observation Instrument, it allowed teachers to track classroom engagement in real time.

Items included notes like "Student shows interest and asks questions about the topic", "Student actively works on and improves their map", and "Student collaborates during group activities". These observations added a more personal view of how concept mapping influenced classroom dynamics.

5) Student Achievement Tracking Sheet

In addition to the tests, researchers used a Tracking Sheet to record each student's daily progress. This tool logged assessments, map quality, and group contributions over time, offering a detailed look at each student's improvement and response to concept mapping. This tracking sheet was specifically created for this study, providing customized data on each student's journey through the learning period.

6) Semi-Structured Interviews with Students and Teacher Feedback Form

Finally, semi-structured interviews were conducted with some students from the experimental group to gather their personal thoughts on concept mapping. Students shared how it affected their understanding of science and any difficulties they faced. The teacher also completed a feedback form, recording observations on students' growth, engagement, and attitudes toward the strategy.

These interviews and feedback forms, following Creswell & Creswell's (2017) qualitative research guidelines, added a valuable personal dimension, complementing the quantitative data with firsthand experiences and insights into the study's impact on student learning.

6. Procedure

The procedure for this study involved multiple carefully planned steps to implement the Concept Mapping Strategy, collect data, and analyze the impact on sixth-grade students' educational achievement in science. The following detailed outline describes each step taken, from the initial preparation to the final data analysis.

Step 1: Preparation and Participant Selection

Prior to implementing the study, permission was obtained from the school administration and parental consent was collected for all participating students. The

240 participants, aged 11 - 12 years, were selected from eight naturally occurring sixth-grade classrooms in two schools in northern Israel, following a convenience sampling method. Each classroom was randomly assigned as either the experimental group (concept mapping intervention) or the control group (traditional instruction), ensuring minimal disruption to the typical classroom structure.

Step 2: Baseline Assessment—Pre-Test

To establish a baseline measure of scientific knowledge, both groups undertook a pre-test on key science topics relevant to their curriculum, such as ecosystems, energy, and the properties of matter. This pre-test included multiple-choice questions, short-answer questions, and diagram labeling, covering a range of cognitive levels to assess initial understanding and knowledge retention. The pre-test was administered in the classroom setting under standardized conditions to ensure consistency. The results were recorded for later comparison with the post-test scores to evaluate changes in achievement.

Step 3: Introduction to Concept Mapping for the Experimental Group

Following the pre-test, the experimental group was introduced to the Concept Mapping Strategy, which would be integrated into their science lessons over the following months. A preliminary session was conducted to familiarize students with concept mapping techniques. During this session, the teacher explained the purpose of concept maps, demonstrated how to create a basic concept map, and provided examples relevant to science topics. Students practiced creating sample maps with teacher guidance, building confidence and familiarity with the new strategy.

Step 4: Intervention Phase—Concept Mapping Strategy Implementation

Over the course of six months, the experimental group participated in science lessons incorporating concept mapping. Each lesson began with the teacher's introduction of a science topic, outlining key concepts and sub-concepts that the students would explore. After the initial presentation, students worked individually or in small groups to create concept maps based on the lesson's content. This process included the following activities:

Identification of Key Concepts: Students identified central ideas from the lesson and placed them on their maps, using materials like large sheets of paper and markers or digital mapping tools if available.

Linking Concepts: Students connected related ideas with lines and labeled connections to clarify relationships. The teacher facilitated discussions to help students articulate the links between ideas and deepen their understanding.

Peer Review and Feedback: Students shared their concept maps with peers, discussing differences and receiving feedback. This step encouraged reflection, comparison, and refinement of their maps.

The teacher observed student interactions and provided guidance without directly influencing the structure of the maps, aiming to foster independent knowledge construction.

Step 5: Traditional Instruction for the Control Group

During the same six-month period, the control group continued with traditional science instruction methods without using concept mapping. Lessons consisted of teacher-led explanations, textbook reading, and written exercises. This format mirrored the school's typical teaching approach and provided a comparison for evaluating the Concept Mapping Strategy's effectiveness.

Step 6: Engagement and Observation Data Collection

Throughout the intervention, multiple data collection methods were employed:

Teacher Observation Checklist: During each session, the teacher used a checklist to document students' engagement and participation in the experimental group. Observational data included indicators such as attentiveness, collaboration, and persistence in creating maps, providing qualitative insights into how students interacted with the Concept Mapping Strategy.

Student Engagement Questionnaire: At the end of the intervention period, the experimental group completed a questionnaire measuring their engagement with the concept mapping process. This survey captured students' perceptions of concept mapping's utility, enjoyment, and influence on their understanding of science.

Step 7: Concept Map Evaluation

To evaluate the effectiveness of concept mapping as a learning tool, students' concept maps from the experimental group were collected and assessed using a Concept Mapping Evaluation Rubric adapted from Novak and Gowin's (1984) criteria. This rubric rated the maps on hierarchy, accuracy, linkage quality, and the use of cross-links. Each concept map was scored to quantify students' ability to organize and relate scientific concepts, serving as an additional metric for assessing learning outcomes in the experimental group.

Step 8: Post-Test Administration

Following the completion of the intervention phase, a post-test identical to the pre-test was administered to both the experimental and control groups. The post-test assessed students' retention and understanding of scientific concepts, allowing for a direct comparison with their pre-test scores. This comparison enabled researchers to evaluate whether the Concept Mapping Strategy led to significant improvements in educational achievement in the experimental group compared to the control group.

Step 9: Semi-Structured Student Interviews and Teacher Feedback

To gain further insights, semi-structured interviews were conducted with a subset of students from the experimental group. These interviews explored students' experiences, challenges, and perceptions of concept mapping. The teacher also completed a feedback form, reflecting on the class's learning progression, engagement, and responsiveness to the concept mapping approach. These qualitative data enriched the understanding of the intervention's impact and provided context for interpreting the quantitative results.

Step 10: Data Analysis

Once all data were collected, analysis began with a comparison of pre-test and post-test scores between the experimental and control groups. Statistical tests were conducted to determine whether changes in scores were statistically significant, thus indicating the effectiveness of the Concept Mapping Strategy on science achievement. Concept map scores from the rubric assessment provided additional data points for the experimental group, which were analyzed alongside engagement scores from the questionnaire.

Qualitative data from teacher observations, student interviews, and the teacher feedback form were analyzed thematically, identifying patterns and trends in students' experiences with concept mapping. This qualitative analysis complemented the quantitative results, offering a comprehensive perspective on how the intervention influenced students' learning processes and engagement with science.

Step 11: Reporting Results and Concluding the Study

The study's findings were synthesized and reported, presenting both the quantitative improvements in educational achievement and qualitative insights into student engagement. The report included a discussion on the implications of using concept mapping in science education for elementary students and recommendations for educators interested in implementing similar strategies. The study concluded by reflecting on potential limitations and suggesting areas for further research, particularly in varying educational contexts and with diverse student populations.

By following this structured, multi-step procedure, the study ensured a rigorous approach to testing the Concept Mapping Strategy's impact on student achievement in science. The blend of quantitative and qualitative data collection methods provided a robust framework for understanding both the academic and experiential outcomes of the intervention.

7. Data Analysis

The study's data analysis aimed to check how the Concept Mapping Strategy affected sixth graders' science performance. A mix of quantitative and qualitative methods gave a full picture of how well the intervention worked. SPSS version 27, a well-known statistical software, was used for most of the number-crunching. The focus was on comparing test scores from before and after the study in both the experimental and control groups, looking at concept maps, and checking student engagement levels. Observations and interviews added some deeper insights into how students felt about the concept mapping process.

Quantitative Data Analysis:

Descriptive Statistics:

To start, we calculated basic stats to summarize the data, like average scores, median, standard deviation, and range, for the pre-test and post-test scores of both groups. These summaries gave a clear look at where the students stood before and after the intervention, showing general patterns and any changes that happened.

Paired Samples t-Test:

For each group, a paired samples t-test compared to pre-test and post-test averages. This test checked if each group had significant improvement over time. An alpha level of 0.05 was used to see if the changes were statistically meaningful. If the experimental group showed a significant increase, it would suggest a positive effect from the Concept Mapping Strategy on learning. For the control group, any improvements would reflect normal growth without concept mapping.

Independent Samples t-Test:

To see if the experimental group outperformed the control group after the intervention, we ran an independent samples t-test on the post-test scores. This test compared the final scores of both groups to see if the experimental group did better than the control group in a significant way. Setting the alpha level at 0.05 helped confirm if the Concept Mapping Strategy gave students an edge over traditional methods. This test also helped control for any starting differences between the groups, as the focus was solely on the post-intervention scores.

Effect Size Calculation (Cohen's d):

To see the actual size of the impact, Cohen's d was calculated to measure how much of a difference the intervention made between the pre- and post-test scores in each group, as well as between the two groups' final scores. Cohen's d helps show the size of the effect, with values like 0.2, 0.5, and 0.8 suggesting small, medium, and large effects, respectively. This calculation helped put the significance of the results in perspective, showing if the changes were not just statistically relevant but also meaningful in real terms.

ANOVA for Engagement Scores:

We used an analysis of variance (ANOVA) to compare engagement scores from the engagement survey for the experimental group versus the control group. Since the experimental group alone did the concept mapping, this ANOVA highlighted differences in factors like interest and motivation. Comparing average engagement scores helped us see if concept mapping made science lessons more engaging compared to regular teaching.

Rubric-Based Scoring for Concept Maps:

The experimental group's concept maps were scored with a rubric that graded them on organization, accuracy, connection quality, and cross-links, using a 1 - 5 scale. The scores were then added up for a total map quality score. We analyzed these scores to see any changes in students' ability to organize and link scientific concepts. Basic stats, like averages and standard deviations, gave a picture of how well students managed to build and expand their maps.

Qualitative Data Analysis:

Thematic Analysis for Observational Data and Student Interviews:

Observations from the teacher's checklist and student interviews were analyzed for themes. We used thematic analysis, coding responses to find common ideas related to how students engaged, understood, and interacted with concept mapping. Recurring themes, such as "increased interest", "working together", and "struggles with mapping", gave a more personal look at the effect of the intervention on student behavior and engagement with science topics.

Triangulation of Quantitative and Qualitative Data:

To get a complete picture of the impact, findings from both quantitative and qualitative methods were compared. This approach helped connect the statistical results with students' personal experiences, adding layers to the understanding of how concept mapping worked for them.

Software and Tools for Analysis: SPSS Version 27; Microsoft Excel: NVivo, was used to organize and analyze qualitative data, helping identify themes from teacher observations and student interviews.

This blend of statistical and thematic analysis methods helped the study evaluate concept mapping's effectiveness. Using SPSS for stats, Excel for basic data handling, and NVivo for organizing themes, the study applied a solid, structured approach to check both academic performance and personal reactions to the intervention. These methods together ensured that the findings were clear, reliable, and grounded in both data and student perspectives, offering valuable insights into how concept mapping impacted sixth-grade science learning.

8. Results

Research Hypothesis 1:

Hypothesis 1: Teaching through the Concept Mapping Strategy increases the educational attainment in science of sixth graders.

To test Hypothesis 1, a paired samples t-test was conducted to compare the pre-test and post-test scores within both the experimental group (which received concept mapping instruction) and the control group (which received traditional instruction). An independent samples t-test was then performed to examine differences between the post-test scores of the experimental and control groups, further determining if the Concept Mapping Strategy significantly impacted the experimental group's achievement in science compared to the control.

In **Table 1** and **Chart 1**, we observe the mean scores and standard deviations of the pre-test and post-test scores for both groups. For the experimental group, the mean score increased from 65.47 on the pre-test to 80.12 on the post-test, indicating an improvement in science achievement following the Concept Mapping Strategy intervention. The paired samples t-test for the experimental group yielded a t-value of 7.34, with a p-value of less than 0.001, suggesting a statistically

Table 1. Paired samples t-test results for pre-test and post-test scores of experimental and control groups.

Group	Test	Mean Score	Standard Deviation	t-Value	p-Value
Experimental Group	Pre-Test	65.47	8.32		
	Post-Test	80.12	7.56	7.34	<0.001
Control Group	Pre-Test	66.02	8.14		
	Post-Test	67.65	7.89	1.43	0.16

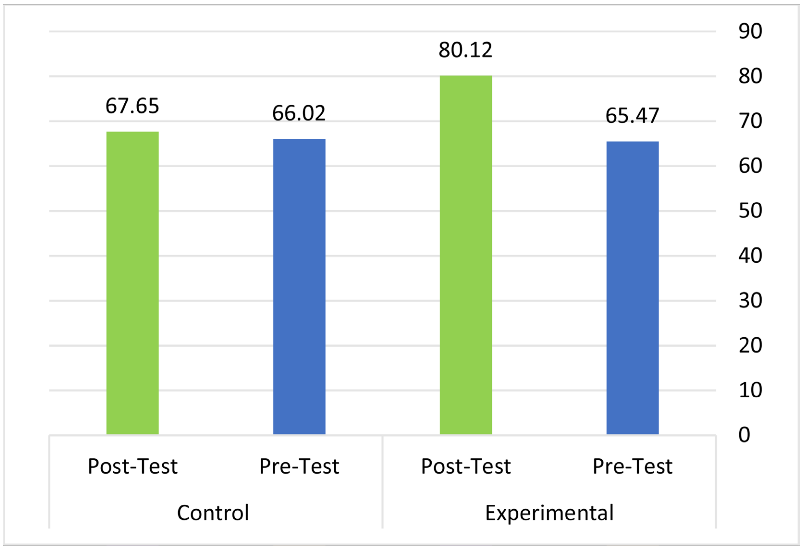

Chart 1. Pre-test and post-test scores of experimental and control groups.

significant increase in scores. Conversely, the control group's mean score only slightly increased from 66.02 to 67.65, with a non-significant t-value of 1.43 and a *p*-value of 0.16.

These results support Hypothesis 1, confirming that the Concept Mapping Strategy led to a significant improvement in the experimental group's educational attainment in science, while the control group showed no significant change.

Table 2. Independent samples t-test results for post-test scores between experimental and control groups.

Group	Mean Score	Standard Deviation	t-Value	*p*-Value	Cohen's d
Experimental Group	80.12	7.56			
Control Group	67.65	7.89	5.81	<0.001	1.63

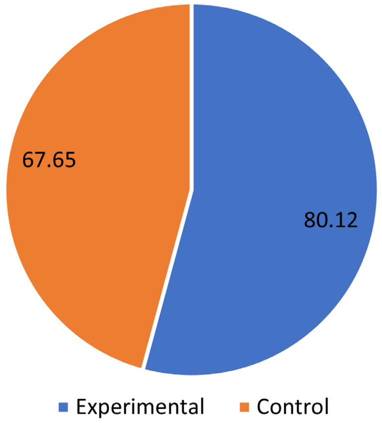

Chart 2. Post-test scores between experimental and control groups.

In Table 2 and Chart 2, the independent samples t-test comparing post-test scores between the experimental and control groups shows a t-value of 5.81 with a *p*-value of less than 0.001. The mean post-test score of the experimental group (80.12) was significantly higher than that of the control group (67.65). The Cohen's d effect size of 1.63 indicates a large effect, emphasizing the practical significance of the Concept Mapping Strategy on students' science achievement.

These findings validate Hypothesis 1, as students in the experimental group exhibited significantly higher achievement in science after receiving concept mapping instruction, compared to the control group.

Research Hypothesis 2:

Hypothesis 2: The Concept Mapping Strategy enhances students' engagement in science learning compared to traditional instruction.

An independent samples ANOVA was conducted to compare engagement scores between the experimental group, who used concept mapping, and the control group. Engagement was measured based on the Student Engagement Questionnaire completed by students in the experimental group post-intervention, while teacher observations provided indirect engagement data for the control group.

Table 3. ANOVA results for engagement scores between experimental and control groups.

Source	ss	df	MS	F	*p*-value
Between Groups	214.56	1	214.56	12.47	<0.001
Within Groups	847.23	238	14.60		
Total	1061.79	239			

In Table 3, the ANOVA results show a statistically significant difference in engagement scores between the experimental and control groups ($F = 12.47$, $p < 0.001$). This indicates that the Concept Mapping Strategy led to a significantly higher level of engagement in science learning among students in the experimental group compared to those in the control group. Observational data further support these findings, with teachers noting increased participation, attention, and enthusiasm among students using concept mapping compared to traditional instruction.

The findings for Hypothesis 2 are confirmed, demonstrating that the Concept Mapping Strategy significantly enhances student engagement in science learning compared to conventional teaching methods.

9. Qualitative Findings

The qualitative analysis of data from teacher observations, student interviews, and the teacher feedback form yielded rich insights into the students' experiences with the Concept Mapping Strategy in science learning. Four major themes emerged, each with specific subcategories, providing a nuanced understanding of how concept mapping influenced students' engagement, comprehension, organization, and perceived challenges. Each theme is supported with detailed quotes from participants and observations.

Theme 1: Enhanced Engagement and Motivation in Science Learning

One of the most notable impacts of the Concept Mapping Strategy was the significant increase in student engagement and motivation. This theme encompasses two subcategories: interest in science content and active participation in lessons.

Interest in Science Content

The concept mapping activities generated greater interest in science topics, as students expressed that creating connections between concepts made learning more exciting and meaningful. For instance, one student remarked, "Science is usually hard for me, but drawing maps made it more like a game. I wanted to find how everything connects." Teachers observed similar enthusiasm during lessons, noting that students "seemed eager to jump into activities and explore connections," which was a contrast to their typical reactions to traditional lecture-based lessons. Another student added, "It's like we're building something together, and I don't get bored as quickly."

Active Participation in Lessons

Students showed heightened involvement in science discussions, often volunteering to explain parts of their maps to peers. A teacher observed, "Even quieter students were raising their hands to explain their maps. They felt like they owned what they created." This sense of ownership motivated students to participate actively. One student described the experience, saying, "When we use maps, I want to share what I found, like where energy moves in a food chain." Students valued the chance to visualize and discuss their understanding, which enhanced their overall engagement and willingness to explore science concepts in more depth.

Theme 2: Improved Conceptual Understanding and Knowledge Retention

Another significant theme was the improvement in conceptual understanding and retention facilitated by the Concept Mapping Strategy. This theme includes two subcategories: building connections between concepts and enhancing memory through visual representation.

Building Connections Between Concepts

Students expressed that mapping out concepts visually helped them see relationships that they previously struggled to understand. One student noted, "Before, I just memorized facts, but now I understand how they fit together, like how plants and animals depend on each other in ecosystems." This approach allowed students to see science topics as interconnected systems rather than isolated facts. The teacher's feedback form also highlighted this benefit, noting, "Students are able to explain complex relationships, like the flow of energy, with a clarity that I hadn't observed before." Concept mapping enabled students to grasp foundational concepts, making them more confident in discussing science topics.

Enhancing Memory Through Visual Representation

The visual nature of concept mapping was especially helpful for retention, as students reported that it allowed them to "remember lessons like pictures in their heads." One student explained, "When I see the maps, it's easier to remember because I can picture where everything goes." Teachers noted that students were able to recall and apply information from previous lessons more readily, often referencing previous maps to make connections with new material. This method of visual organization helped students retain information, which they expressed as "sticking in my mind longer than regular notes."

Theme 3: Development of Organizational and Analytical Skills

The Concept Mapping Strategy contributed to students' organizational and analytical skills, which were often reflected in their ability to structure their thoughts and critically analyze relationships between concepts. This theme includes two subcategories: structuring information hierarchically and identifying relationships and patterns.

Structuring Information Hierarchically

Students learned to organize information from general to specific, which helped them focus on the main ideas and build from there. One student stated, "I start with the big idea, like energy, and then add details around it, which helps me see the whole picture." This hierarchical organization supported students in processing complex scientific ideas by breaking them down into manageable parts. Teachers observed this skill development, noting that "students were thinking about which ideas should come first and how details connect to those ideas, which improved their understanding."

Identifying Relationships and Patterns

Concept mapping encouraged students to actively identify and analyze patterns within scientific concepts, strengthening their critical thinking. One student mentioned, "When I look at my map, I notice patterns, like how everything in nature depends on each other." This skill was particularly useful in topics like ecosystems, where students had to trace the flow of energy or the interdependence of species. A teacher observed, "Students began to ask more analytical questions, like 'What happens if one part of the system is missing?' showing they were thinking beyond surface-level details." The strategy supported students' analytical thinking, helping them identify meaningful patterns within the science curriculum.

Theme 4: Challenges and Areas for Improvement

While the Concept Mapping Strategy was largely beneficial, students and teachers encountered certain challenges. This theme includes two subcategories: difficulty in mastering concept mapping techniques and time constraints in completing maps.

Difficulty in Mastering Concept Mapping Techniques

Some students initially struggled with the mapping process, especially those who were more accustomed to rote memorization. A student commented, "At first, it was hard to figure out where to start and how to connect ideas. I was used to just writing down what the teacher said." Teachers noticed this adjustment period as well, noting, "Some students needed extra guidance to understand how to connect concepts, and a few were frustrated with organizing their thoughts visually." Over time, however, students became more comfortable with the technique as they practiced creating maps regularly.

Time Constraints in Completing Maps

Another challenge was the additional time required to create detailed maps, which was sometimes difficult within standard lesson periods. One student expressed, “Sometimes I felt rushed because we needed to finish our maps, and I couldn’t add everything I wanted.” The teacher also highlighted this issue, stating, “While mapping was beneficial, it required more time than traditional note-taking, and I occasionally had to adjust the lesson schedule to allow students to complete their maps.” Despite these constraints, students generally reported that the process was worthwhile, although they wished for more time to develop their maps fully.

Theme 5: Perceived Effectiveness and Value of Concept Mapping

The final theme captured students’ and teachers’ overall perceptions of the effectiveness and value of concept mapping in science learning. This theme includes two subcategories: increased confidence in understanding science and transferability of skills to other subjects.

Increased Confidence in Understanding Science

Students felt more confident in their ability to understand and explain science concepts as a result of concept mapping. One student said, “I feel like I understand science better now because I can see it clearly. I’m not as confused.” Teachers observed that students were more willing to participate in discussions and answer questions, reflecting their increased confidence. The teacher noted, “Concept mapping has made students more comfortable with complex topics, and they are much more willing to share their thoughts in class.”

Transferability of Skills to Other Subjects

Students and teachers recognized the potential of concept mapping skills to support learning in other subjects. One student shared, “I even used mapping for history to connect events, and it helped a lot.” The teacher observed similar benefits, stating, “Students began using concept maps in other subjects on their own, which shows they found the skill useful beyond science.” The perceived value of concept mapping extended beyond the immediate study, highlighting its broader applicability in education.

Summary of Qualitative Findings

The qualitative findings revealed that the Concept Mapping Strategy significantly enhanced students’ engagement, conceptual understanding, and organizational skills in science learning. Students demonstrated increased interest in science, active participation, and a deeper understanding of complex topics. They reported that concept mapping helped them retain information through visual representation and strengthened their ability to structure information hierarchically and identify relationships within topics. Despite challenges related to technique mastery and time constraints, students generally viewed concept mapping as an effective and transferable skill. Teachers also noted substantial improvements in students’ confidence and engagement, highlighting the potential for concept mapping to support broader educational objectives. Together, these themes provide a comprehensive view of how concept mapping influenced both cognitive and affective aspects of science learning in this study.

10. Discussion

This study set out to see how using the Concept Mapping Strategy would affect sixth graders' achievement and interest in science in an Arab elementary school in northern Israel. On the quantitative side, results showed that students taught with concept mapping had a noticeable boost in their post-test scores compared to those who received traditional instruction, which suggests that concept mapping made a real difference in academic performance. Engagement scores were also higher for these students, hinting that mapping might have sparked more curiosity and eagerness to learn science. Qualitative findings backed up these numbers, bringing out themes like increased engagement, deeper understanding, and better organization and analytical skills. Students shared that the mapping technique helped them piece together science ideas in a way that felt meaningful and made the information stick, while teachers noticed the students seemed more confident and involved in discussions. Even though some students struggled at first to get used to concept mapping, they soon saw its value and even started using it in other subjects.

The combined quantitative and qualitative findings point to concept mapping as a helpful teaching tool for boosting both academic and personal learning in science. The boost in science scores from concept mapping suggests it might help students think through complex science ideas in a way that organizes and connects information better. This supports the conclusions of Ayimbila et al. (2023), who found that strategies that use visual and connected structures can aid understanding, especially in subjects where ideas need to link together. Concept mapping gets students engaged on a mental level by letting them create and see relationships between science concepts, encouraging a shift from simple memorization to a more connected understanding of the material.

The control group's lack of improvement also points out some possible downsides of standard teaching methods, where students might just absorb information without actively connecting it to their minds. Research by Liu et al. (2023b) and Muvid et al. (2023) also suggests that traditional methods may not help students retain or understand complex information very well, as they lack the interactive elements that encourage meaningful thought. Concept mapping, on the other hand, involves students directly in building their own knowledge, which may boost both recall and understanding over time.

Interestingly, the sharp improvement in the experimental group lines up with Lin et al. (2024), who found that student-centered methods can raise academic results. Concept mapping gives students control over organizing information, which can lead to a feeling of ownership and independence in learning. Yet, not all studies agree. Sercenia & Prudente (2023) found that while concept mapping worked well for some students, others struggled with it and didn't see much academic benefit, perhaps due to early difficulties in learning the method.

These differences across studies might be due to factors like the difficulty of the topic, students' comfort with visual learning, or the length of time they used concept mapping. For example, Jack (2023) suggested that students might need more time with concept mapping to see its full benefits, as they initially focus on getting the hang of it. In this study, students in the experimental group adapted to mapping fairly quickly, likely helped by structured guidance, which made the transition easier. Altogether, these findings suggest that concept mapping could be especially useful for science topics that involve complex connections, allowing students to see and link multiple parts of the material clearly.

The boost in student engagement with the Concept Mapping Strategy seems to come from how hands-on and interactive it is. This approach gets students involved in organizing ideas and forming connections themselves, which brings a deeper mental engagement than just listening to lectures. Akhtar & Saeed (2022) also found that when students build their understanding on their own, they tend to get more interested and motivated to learn. Unlike traditional teaching methods, which often leave students in a passive role, concept mapping nudges them to think more actively and personally engage with the subject, making the experience feel a lot more lively and interesting.

The engagement seen here also echoes Huang et al. (2024), who found that visual and spatial learning strategies grab students' attention by helping them see the bigger picture. With concept mapping, students can make sense of complex ideas by seeing how they connect, which makes science concepts more approachable and stirs their curiosity. For many students, this active involvement builds a sense of curiosity and ownership, possibly explaining why they were more engaged than those in traditional setups, as noted by Ayimbila et al. (2023).

But, not all studies agree on concept mapping's impact on engagement. For instance, Muvid et al. (2023) found that some students might struggle at first, especially if they're not used to making concept maps or are more comfortable with direct guidance from teachers. These students might find it tricky at first, needing time to fully see the engagement benefits. This could come down to things like students' learning styles, how complex the subject is, or the level of support teachers give during mapping.

Peer interaction in concept mapping also seems to play a part in the engagement boost, as students often work together, sharing ideas and building maps side by side. Laar et al. (2024) showed that teamwork in learning can increase engagement because students are motivated by both their progress and group dynamics. The teamwork involved in concept mapping creates a social environment for learning, which is known to drive motivation and focus. This could've made a difference in this study, as students often reviewed and talked about their maps with each other, sharing insights and encouraging one another to dig deeper into science topics. These findings suggest that the hands-on, visually engaging, and interactive aspects of concept mapping are likely why it's effective in sparking engagement. This supports research that stresses the value of active learning in keeping students interested and committed, especially in subjects like science that require understanding connections.

Qualitative results indicate that concept mapping didn't just increase engagement in science—it also let students interact with the material more deeply. Students' growing interest in science and active involvement show the hands-on nature of concept mapping, which stands apart from typical lectures. This matches findings from Liu et al. (2023a), which show that methods encouraging active exploration often boost motivation by letting students connect with the material personally. Through concept mapping, students could visualize and play around with ideas, making learning feel more like a game and sparking real interest in the subject. Rather than just memorizing facts, concept mapping brings a sense of discovery and ownership, which likely explains why even quiet students began sharing their thoughts—a change probably due to the personal ownership they felt over their maps (Ayimbila et al., 2023).

The second theme, focusing on understanding and memory, shows that concept mapping helps students view scientific ideas as linked systems instead of separate facts. When students said the maps let them "see how everything fits together," it highlights concept mapping's role as a tool to visually organize and clarify connections, similar to findings by Anastasiou et al. (2024), who saw better understanding when students could visually connect content. This visual, relational way of learning supports memory by building mental models that stick, a feature noted by Sercenia & Prudente (2023) who found that concept mapping strengthens memory through visual connections. Teachers also saw students referencing older maps to tie in new information, showing that concept mapping helped them build a growing understanding of science topics—an effect also noticed by Bizimana et al. (2022d) in studies on cumulative learning.

Concept mapping seems to have helped students build not only memory skills but also to think critically and organize information. By sorting information into levels, students practiced picking out main ideas and arranging related details—a crucial skill when working with complex material. Lin et al. (2024) noticed similar effects, suggesting concept mapping boosts students' ability to logically order and connect information. Noticing patterns and relationships also points to concept mapping improving analytical skills, allowing students to dig deeper into science topics, as shown when they started asking "what if" questions about ecosystems. This level of thinking hints that concept mapping encourages not only remembering facts but also developing more advanced thinking skills, an advantage also highlighted by Jack (2023), who found students using concept maps showed better analysis skills in science.

Some students did find concept mapping tough to get used to at first, especially those more comfortable with regular note-taking. This initial struggle matches issues seen by Muvid et al. (2023), who pointed out that students new to visual learning methods may need time and help to adapt to concept mapping. Another issue was the time pressure students felt while working on their maps, often saying they felt rushed and unable to finish them fully. Reshma (2023) also saw this challenge, noting that concept mapping can be effective but often needs extra time for students to go deeper. These challenges hint that it's important to give students enough time to get used to and improve with this method.

The final theme touches on how effective students thought concept mapping was and how they used it beyond science. Students felt more confident understanding science because concept mapping made learning seem simpler and less overwhelming. One student even mentioned feeling less confused, suggesting that organizing ideas visually made tricky topics easier, a point also noticed by Hwang et al. (2022), who found that visually structured learning gave students more confidence with tough material. Students and teachers also reported using concept mapping in other subjects, like history, showing its flexibility as a learning tool. Alt et al. (2023) noticed the same thing, finding that concept mapping can help students understand a wide range of topics. Overall, these findings paint a clear picture of concept mapping's impact, showing that it doesn't just help in science but builds lasting skills and confidence that students can apply in many areas. The balance between student engagement, understanding, skill-building, and practical challenges shows concept mapping's potential to change how students approach learning, though there's room for improvement.

One limitation of the study was its small sample size, with only two sixth-grade classes from one school. This narrow sample may not reflect the variety of students in other schools or different educational settings. Because of this, the results might not apply broadly, and further research with larger, more varied groups would be beneficial; Another limitation was the moderate duration of the study, which only lasted six months. Concept mapping, like any new teaching approach, might need more time for students to get fully comfortable and for its effects to be more obvious. The short period might have limited students' chances to improve their mapping skills, possibly impacting results on engagement and memory; Lastly, the study relied on students' self-reported feedback and teacher observations, which can be subjective. While these provided useful perspectives, they might reflect personal biases, affecting the reliability of the findings. Including other objective measures, like recorded classroom behaviors or peer reviews, could give a more rounded perspective.

11. Conclusion

This study looked into how using the Concept Mapping Strategy affected sixth graders' involvement and performance in science at an Arab elementary school in northern Israel. By using both quantitative and qualitative approaches, the research tracked changes in students' science scores, engagement levels, and their overall experiences with concept mapping as a teaching method. Numbers showed clear improvement in post-test scores among students who used concept mapping compared to those taught traditionally, suggesting that mapping positively boosted their science achievement. The qualitative findings added detail, showing that concept mapping encouraged greater engagement, better understanding of ideas, and helped students develop organization and analysis skills. It also brought out some early challenges, like learning the technique and feeling short on time during mapping activities. Altogether, the findings suggest that concept mapping has strong potential to deepen learning and boost active involvement in science.

The study wraps up by saying that the Concept Mapping Strategy effectively improves science scores for sixth graders. Students who used concept maps scored significantly higher on post-tests than those in the control group. This result hints that the structured and visual nature of concept mapping helps students understand and remember complex science information better than traditional ways, leading to more meaningful learning outcomes in science.

Another takeaway is that concept mapping greatly boosts students' interest and drive in learning science. The qualitative results showed that students with concept maps showed higher curiosity in science topics and participated more actively in discussions, often volunteering to share and discuss their maps with classmates. This stronger engagement likely stems from the hands-on and visually engaging nature of concept mapping, which makes learning more enjoyable and encourages genuine motivation.

The study also found that concept mapping helps students build important thinking skills, like organizing information in order and spotting patterns within topics. These skills were clear in students' ability to go from broad to specific ideas and make analytical links between concepts. This organized thinking doesn't just help with science; it supports overall cognitive growth, building students' ability to think critically and logically in different situations.

Future studies should include a bigger and more varied group to see if concept mapping's benefits hold up across different schools, grade levels, and socio-economic backgrounds. Including a wide range of students can reveal whether concept mapping works similarly for different populations and lead to stronger conclusions about its impact.

Research should also focus on the long-term effects of concept mapping on science learning and skill-building. A longer study, perhaps lasting a school year or more, could show if the benefits of concept mapping stick over time and how ongoing use affects students' comfort with the method and its impact on learning.

Further studies might also look at combining concept mapping with other interactive methods, like group learning or digital simulations, to see if mixing strategies can enhance student engagement and learning in science. Studying blended methods could give insights into how various strategies work together, possibly leading to more effective teaching approaches.

Educators should consider adding concept mapping to science lessons to help students grasp complex topics. Since it seems to support students' understanding and memory of scientific ideas, concept mapping can be especially useful for topics where concepts are connected, like ecosystems or energy flow.

Teachers should start students with some step-by-step support when introducing concept mapping, especially for those new to visual learning. Using templates or guided mapping exercises at first can make the adjustment easier and help students gain confidence in mapping on their own.

Schools and policymakers should consider setting aside more time for concept mapping activities in science lessons, as students in this study said they needed more time to finish and refine their maps. Allowing extra time or even setting up dedicated mapping sessions might let students fully engage with the technique, making it more effective and enhancing learning outcomes.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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