



Research Article

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The Effectiveness of The Concept Mapping Strategy in Developing of Digital Concepts Among Students at Prince Sattam bin Abdulaziz University

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Abstract

This study aimed to explore the efficacy of concept mapping in enhancing digital concept development among female undergraduate students enrolled in a computer skills course. A total of 70 participants were randomly assigned to either an experimental group instructed through concept mapping, or a control group taught using traditional methods. The experimental group, utilizing concept mapping, significantly outperformed the control group in posttest assessments of digital concepts ($p < 0.05$). These findings suggest that concept mapping can effectively boost digital literacy within computer skills education. Recommendations encompass the integration of concept mapping in computer and digital skills courses, offering training to both educators and students on the use of concept mapping, and the active incorporation of this strategy across educational levels. In summary, this investigation underscores the significance of concept mapping as a potent instructional approach for cultivating fundamental digital competencies.

Keywords: Effectiveness, Concept Mapping, Digital Concepts, Female Students, Computer Skills

1. Introduction

University students are considered an important human resource upon which countries focus for academic, technological, social, and ethical development. This focus stems from their anticipated pivotal roles in various professional sectors in the future (Alqahtani & Ayentimi, 2021). Consequently, responsible educational institutions seek to equip students with the necessary skills demanded by the present century. This preparation enables them to navigate the era's changes, confront its rapid challenges, and contribute to a better future for themselves and society. Among the most crucial skills university students should acquire in the 21st century are critical thinking, communication proficiency, technological literacy, collaboration, and leadership (Kirschner et al., 2006).

To attain technological proficiency, students must possess a certain level of computer literacy and grasp digital concepts. These concepts, encompassing hardware, software, operating systems, networks, and security, form the bedrock of digital literacy. Given the rapid advancements in information and communication technology that have transformed all aspects of life, nations are keen on eradicating computer illiteracy and enhancing digital concept knowledge among their

populations. Virtually every educational system incorporates courses such as digital technology or computer skills into their curriculum to teach these concepts (UNESCO, 2015).

The teaching of digital technology to students comprises three branches: digital concepts and applications, computational thinking and programming, and digital citizenship. Teaching fundamental digital concepts serves as the starting point for mastering the other branches. According to Bruner (1960), students' comprehension of the cognitive structure of concepts significantly influences the effectiveness of their learning. Proficiency in fundamental digital concepts empowers students to manipulate digital knowledge, generate new insights, and identify new relationships within the digital realm. This elevates their learning efficacy and their ability to retain and apply digital knowledge when needed. It also instills self-motivation for continued and enthusiastic digital skill acquisition. Students cannot master the use of computers and similar devices without understanding their components, functions, interrelationships, operation mechanisms, maintenance and repair, various applications, and uses (Mintzes et al., 2005).

Various educational theories, including behaviorism, constructivism, and communicative approaches, have diversified the teaching methods and strategies employed in digital technology education. Some methods focus on reinforcing and supporting positive learner behavior, while others encourage student interaction and the application of prior knowledge to build new knowledge. Some methods involve breaking down the subject's overall content into parts for deeper understanding. However, some argue that the most effective teaching strategies emerge from cognitive learning theories, particularly within the constructivist framework. According to Wheatly (1991), these theories rest on three pillars: prior experiences, mental schemata, and student beliefs. One such effective strategy is the use of concept maps. Joseph Novak created concept maps in the 1970s, which are graphical representations of concepts and their hierarchical relationships (Novak, 1990).

Concept maps guide learners toward a more profound understanding of digital concepts, enabling them to distinguish between fundamental and less general sub-concepts. This boosts learner confidence, engagement in the learning process, and the acquisition and retention of digital concepts. It also aids in comprehending the structure of digital knowledge formation. Additionally, concept maps help students improve their metacognitive skills by letting them explore the structure of digital knowledge. This lets them find relevant digital concepts and make connections between new digital concepts and what they already know about digital concepts (Al-Khawaldeh, 2007).

Hence, many educators have incorporated concept mapping into their digital literacy teaching strategies due to its positive impact on students' engagement, learning, and retention of digital concepts. This takes into account the time spent by learners processing and organizing digital information. The quality of relationships depicted in concept maps encourages learners to expand their digital knowledge and attempt to connect new and prior digital knowledge, providing meaningful insights when constructing the concept map (Odem & Kelly, 2005).

2. Problem Statement

Digital literacy, involving the comprehension and application of technology, computing, and digital media concepts, holds increasing significance in today's tech-driven world. This importance is particularly pronounced for female university students, who often encounter unique challenges in developing these skills, challenges that are sometimes exacerbated by traditional teaching methods. Despite prior exposure to certain digital literacy concepts, a noticeable gap in comprehension persists among these students. This discrepancy was evident in a survey conducted with 28 female students from the College of Education at Prince Sattam bin Abdulaziz University, where only 22% demonstrated a correct understanding of the selected concepts.

Prior research has underscored the effectiveness of concept mapping in enhancing student learning and comprehension. As a result, this study aims to investigate whether the concept mapping strategy could facilitate the learning of digital literacy among female students at Prince Sattam bin Abdulaziz University. The study seeks to determine the effectiveness of this strategy by comparing

the performance and comprehension of students taught using concept mapping with those taught through more traditional methods.

This research endeavors to contribute to educational literature by providing empirical evidence regarding the effectiveness of concept mapping in teaching digital literacy. The findings are expected to offer valuable insights for educators, curriculum planners, and stakeholders in higher education, aiding them in devising more effective approaches to teaching digital literacy within college settings.

3. Research Questions

The main Question of this paper is What is the effectiveness of the concept mapping strategy in developing digital literacy concepts among female students enrolled in the computer skills course at Prince Sattam bin Abdulaziz University in Al-Kharj?

4. Research Objectives

To determine the effectiveness of the concept mapping strategy in developing digital literacy concepts among female students enrolled in the computer skills course at Prince Sattam bin Abdulaziz University.

5. Research Methodology

5.1 Approach

This study employed a quasi-experimental pretest-posttest control group design to assess the effectiveness of the concept mapping teaching strategy in enhancing students' understanding of digital concepts. This design enabled the researcher to establish equivalence between the control and experimental groups before implementing the intervention. It also let researchers look at the effect of the independent variable (concept mapping strategy) by comparing the two groups' post-test scores and considering their pre-test scores (Creswell, 2022).

The participants in the study were randomly assigned to either the control group or the experimental group to ensure the validity of the experiment. The control group received instruction through traditional teaching methods, such as lectures, presentations, and handouts. In contrast, the experimental group was trained in the utilization of the concept mapping strategy, which is based on Novak's principles and consists of four main steps: introduction, clarification, synthesis, and evaluation (Novak & Canas, 2008).

Various digital technologies were incorporated into the concept mapping activities, including web-based collaborative concept mapping applications (CmapTools), MS PowerPoint, and multimedia resources. The concept mapping sessions involved practices such as collaborative brainstorming to elicit prior knowledge, instructor-led concept map creation, student-generated concept maps, peer evaluation, and concept map-based assessments.

5.2 Research Population and Sample

The target population consisted of all 385 female students enrolled in the "Computer Skills" course at Prince Sattam University in Al-Kharj during the 2022–2023 academic year. Cluster random sampling was utilized, whereby two course sections were randomly selected out of all the sections. This yielded an initial sample of 72 students.

Simple random sampling was then used to assign one section as the control group ($n = 37$) and the other as the experimental group ($n = 35$). Students who had previously taken the computer skills course were excluded to avoid influencing the results. The final sample consisted of 70 students, with 35 in each group.

The study involved 70 female undergraduate students enrolled in the "Computer Skills" course at Prince Sattam bin Abdulaziz University. These participants were majoring in various disciplines, providing a diverse academic background that ranged from the humanities and social sciences to the natural and applied sciences. This diversity is crucial for assessing the effectiveness of the concept mapping strategy across a broad spectrum of academic disciplines.

Prior to the intervention, an initial assessment of the participants' digital literacy skills was conducted through a pre-test. The results indicated a wide range of proficiency levels in basic computer skills, from novice to intermediate, with many students demonstrating a basic understanding of digital concepts such as word processing, internet browsing, and email usage. However, a gap was evident in more advanced skills, including understanding of software applications, data analysis tools, and digital security principles. This variation in digital literacy levels highlights the importance of employing teaching strategies, like concept mapping, that can accommodate diverse learning needs and promote the development of digital competencies effectively.

By providing a detailed account of the participants' academic backgrounds and initial digital literacy skills, this study aims to contribute to the literature on digital literacy education. It underscores the potential of concept mapping as a versatile teaching strategy capable of supporting digital concept development among university students with varied academic interests and prior digital.

5.3 Research Instrument

Based on the theoretical material of the Computer Skills course, the researcher created a 30-item multiple-choice digital concepts test. The steps involved in creating the instrument were as follows:

1. Clearly identify the test objectives and content areas to be assessed based on the course learning outcomes.
2. Formulated 30 multiple-choice items with 4 options each. Items covered topics like computer hardware, software, viruses, computer operation, maintenance, networks, and societal impacts.
3. I wrote clear instructions for the test and established a scoring scheme of 1 point per correct response.
4. Ensured content validity through expert reviews by faculty members experienced in teaching the Computer Skills course. They evaluated each item for relevance, clarity, accuracy, and scope.
5. We pretested the instrument with 54 students and analyzed the difficulty index, which ranged from 0.31 to 0.64 across items, indicating an appropriate level of difficulty.
6. I made minor modifications based on the pretest results and expert feedback. Confirmed the final 30-item test.
7. Established scoring procedures and cover page requirements (name, ID number).

Thus, the validated Digital Concepts Test served as both the pretest and posttest to assess gains in student learning after the concept mapping intervention.

5.4 Data Analysis

The data was analyzed using SPSS 25. Descriptive statistics, including means and standard deviations, were calculated for the pretest and posttest scores of both groups. An independent sample t-test compared pretest scores to verify group equivalence at baseline. To see what effect the concept mapping intervention had, ANCOVA was used to compare the two groups adjusted mean posttest scores while considering differences between the groups before the test. The level of significance was set at 0.05 a priori.

6. Description of the Methodology

We have elaborated on our methodology to provide a clearer, more comprehensive view of our research process. The "Computer Skills" course, spanning a 14-week semester, was designed to enhance students' proficiency in various digital tools and applications. The curriculum was structured around key areas, including word processing, spreadsheets, presentations, internet navigation, and basic programming concepts, aiming to equip students with a broad range of computer skills relevant to their academic and future professional needs.

The intervention was meticulously planned to incorporate a blend of traditional lectures, hands-on computer lab sessions, and the innovative use of concept mapping to facilitate a deeper understanding of digital concepts. Specifically, the experimental group received additional concept mapping sessions where they were guided to create visual representations of the information covered in the course. This approach was intended to encourage active engagement with the material and promote higher-order thinking skills.

To cater to varying learning preferences and ensure an inclusive learning environment, the teaching methods were diversified. Besides the primary lecturing and hands-on practice, collaborative group activities and peer-to-peer teaching sessions were introduced. These methods aimed to foster a collaborative learning environment and enhance students' ability to work effectively in teams, reflecting real-world scenarios.

7. Study Limitations

1. **Substantive Limit:** The research focused solely on the theoretical part of the computer skills course, limiting the scope to the content covered within ten chapters. This narrow focus might not fully capture the broader aspects of digital concepts, potentially overlooking other relevant areas of digital literacy.
2. **Time Limitation:** The study was conducted during the academic year 2022-2023, which may have restricted the duration of data collection and implementation of the concept mapping strategy. A longer-term study could provide more comprehensive insights into the long-term impact of the strategy on students' digital concept development.
3. **Subject Limitation:** Participant Limitation: This study exclusively focused on female undergraduate students in one specific computer skills course at Prince Sattam University. Concentrating on a single gender in one university course limits the generalizability of findings on the evolution of digital concepts beyond this localized context. The effectiveness of the concept mapping strategy may vary across broader student demographics outside of this narrow participant sample. **Gender Limitation:** The study's participants were limited to female students, which may introduce gender-specific factors that could influence the effectiveness of the concept mapping strategy. This limitation may hinder a comprehensive understanding of how the strategy impacts male students or whether there are any gender-specific differences in learning outcomes.

8. Significance of the Study

This research on the effectiveness of the concept mapping strategy in developing digital literacy concepts among female students at Prince Sattam bin Abdulaziz University in Al-Kharj responds to educational advancements and the need for effective strategies in teaching digital technology curricula. It adds valuable insights to local studies on learning and teaching digital literacy, specifically using concept mapping. The practical significance of this research lies in its potential to offer a mechanism for incorporating concept mapping in various subjects, including digital technology courses, benefiting teachers and faculty members by enhancing students' conceptual understanding and skills. Moreover, it has the potential to raise awareness among university students

about the significance and advantages of concept mapping, potentially motivating them to utilize it in other academic contexts. Additionally, it may serve as a catalyst for experts in science education to train teachers on the effective implementation of the concept mapping strategy both before and during their service as educators. Furthermore, this research sheds light on the importance of conducting further studies on developing different types of digital literacy skills and fostering computational thinking using the concept mapping approach.

9. Research Terminology

- A) **Concept Mapping:** It is a visual tool designed manually or electronically using software or applications. It aims to clarify various digital concepts and their relationships, considering the hierarchy from general to specific in presenting the concept and its subcomponents. It utilizes lines and words to connect the concepts and uses examples and colors to signify meaning and enhance recall. (Novak and Cañas, 2008).
- B) **Concept Mapping Strategy:** It refers to a set of practices and procedures followed by faculty members, students, or both to create diagrams that include a range of digitally organized concepts. It uses lines and words to connect the main and sub-digital concepts and clarify the relationships between them. (Novak and Cañas, 2006).
- C) **Digital Literacy Concepts:** They encompass the facts, knowledge, information, and fundamental principles related to the topics covered in the computer skills course. They include terminology, elements, processes, practices, developmental stages, and more. It is essential for students to possess these concepts to activate them in the learning process, and they are assessed through dedicated tests. (McDermott, 2017).

10. Theoretical Framework and Previous Studies

10.1 Concept Mapping Strategy

The concept mapping strategy is one of the strategies emerging from cognitive constructivist theory. Ausubel (1968) is one of the most prominent individuals to have elucidated his thoughts on the process of teaching and acquiring concepts. He categorized the learning process into four types: reception learning, discovery learning, meaningful reception learning, and meaningful discovery learning. He believes that learners use two methods to link new knowledge with their prior cognitive structure: meaningful learning and rote learning. The method of meaningful learning is better than rote learning or "memorization," whether the learning is receptive or discovery. Ausubel (1963) identified three essential conditions for meaningful learning to occur: The material to be learned should be conceptually clear, presented in language, and with examples related to the learner's prior knowledge; the learner should possess prior knowledge related to the material to be learned; and the learner should be motivated for meaningful learning. This can be achieved through the teacher's use of strategies in both teaching and evaluation that encourage this. Teaching strategies emphasize linking new knowledge to what the learner already knows, and evaluation strategies encourage the learner to use his or her ideas to solve the new problems they encounter. The theory of meaningful learning is based on integrating new knowledge with existing prior knowledge in a meaningful way in the learner's structure.

Ausubel came up with the advanced organizer strategy, which involves giving general introductions with key ideas and general or abstract information to help learners reorganize their existing cognitive structures and make it easier for them to add new information to their existing cognitive structures. Advanced organizers act as a bridge between new knowledge and related prior knowledge in the learner, where this knowledge is integrated by finding relationships and comparisons among them. Ausubel categorized advanced organizers into two types: explanatory organizers for acquiring new concepts and comparative organizers for linking new concepts to prior

concepts.

Concept maps can be considered an advanced model for advanced organizers. Novak relied on Ausubel's learning theory to derive the concept mapping strategy and use it in the processes of learning and teaching. Novak and Caas (1984; 2007), have described concept maps as graphical tools designed to represent and illustrate the relationships among concepts within a specific knowledge field. They serve to visually express the flow within a subject area and highlight the interconnections between basic concepts. Concept maps are arranged in a hierarchical format, with subtopics branching off from a central concept or idea and subsequently being subdivided into more specific concepts. Lines are employed to link one concept to another, with phrases or words annotated on these lines to further clarify the nature of the relationship between the concepts. The organization of the concepts typically follows a hierarchy that progresses from the general to the specific.

Previous studies have examined the effectiveness of concept mapping strategies in enhancing learning outcomes and thinking skills across various disciplines and education levels. However, few studies have specifically explored the potential of concept mapping to improve digital literacy skills. This is a gap that this study aims to fill by adding important digital skills like searching the internet, evaluating online information, digital communication, and social media literacy to the concept mapping activity. The study will examine if concept mapping can effectively build digital literacy capacity among high school students.

It's clear from the definitions that we can infer that concept maps are composed of:

- Scientific concepts, whether they are primary or subsidiary
- Linking words: These are words used to connect two or more concepts.
- Links: These are lines used to connect two or more concepts in the hierarchical sequence.
- Examples: These typically manifest as events or actions that express concepts and are usually not placed within a shape.

The strategy of concept mapping holds significant importance, as several experimental studies have demonstrated its efficacy in enhancing students' educational achievement across different academic levels.

For example, a study by Bousahla and Farhawi (2020) aimed to understand the effect of concept mapping strategies on developing achievements among first-grade primary students in their Arabic language course. The study sample consisted of 56 students, selected intentionally and distributed equally between the control and experimental groups.

Another study by Safdar et al. (2008) aimed to understand the impact of teaching using concept maps on improving the educational attainment level of regular students and those with cerebral palsy in the decimal numbers' unit of the Arabic language course for the sixth grade. The study sample consisted of 196 pupils from various categories (regular, cerebral palsy) in three different schools in Kuwait. The study concluded that concept maps are effective in enhancing cognitive abilities in regular students as well as students with cerebral palsy, while this was not the case for female students with cerebral palsy. The study also noted an increase in positive attitudes towards the Arabic language course among all students.

In a study by Al-Qubeilat and Al-Obaidi (2009), the effectiveness of concept mapping in enhancing achievement and conceptual understanding for solving mathematical problems was examined. The study involved a random sample of 124 tenth-grade students in Jordan, who were divided into four groups. One group served as the control group, while the other three served as experimental groups, with each group being taught using a different concept mapping strategy. (Al-Dhufairi, 2014).

Additionally, various studies have highlighted the role of concept maps in developing different thinking skills. For instance, a study by Ayasrah (2015) demonstrated the effectiveness of concept mapping in fostering reflective thinking and comprehension of jurisprudential concepts among middle-school girls.

Al-Sayfi and Abu Dayak's study from 2017 looked at how successful concept mapping and mind

mapping are at helping sixth-grade science students think creatively and do well in school. The study involved a sample of 70 students, equally divided into control and experimental groups.

Another study by Coutinho (2014) revealed the effectiveness of concept maps in fostering innovative thinking among tenth-grade students studying a science course in Kuwait. The study involved a sample of 73 students, divided into an experimental group of 38 students and a control group of 35 students.

Dexter and Hughes (2011) conducted a meta-analysis showing graphic organizers, including concept maps, positively impact learning for students with learning disabilities (LD). The analysis of 19 studies found a moderate to large effect size, indicating graphic organizers significantly improve academic achievement across subjects. The authors recommend incorporating graphic organizers into instruction for LD students to support learning and comprehension. The visual format seems to benefit these students by helping them grasp concepts and relationships.

Stull and Mayer (2007) examined the effects of learner-generated versus author-provided graphic organizers on learning. In three experiments, students who created their own graphic organizers recalling key ideas from a passage showed better learning and transfer than those who studied pre-made organizers. The benefit occurred for students studying expository passages at a range of ability levels. The authors recommend having students construct their own organizers over studying prepared organizers to promote deeper learning.

The context mapping strategy, emerging from cognitive constructivist theory and developed through various educational research, stands out as a transformative approach in teaching and learning. Its core strength lies in fostering meaningful learning by effectively linking new knowledge with pre-existing cognitive structures, thereby surpassing traditional rote learning methods. This strategy's effectiveness is validated through extensive research across different academic levels and disciplines.

Several studies demonstrate its versatility in enhancing educational achievement and developing critical thinking skills. These investigations span a range of contexts, from primary education to more specialized fields. Furthermore, research highlights the significant benefits of graphic organizers, including concept maps, particularly for students with learning disabilities, suggesting their wider applicability in diverse learning environments.

Additionally, studies exploring learner-generated versus author-provided graphic organizers underscore the importance of active learner engagement. These findings advocate for the advantages of students creating their own graphic organizers to promote deeper understanding and more effective learning.

Finally, concept mapping is revealed as a vital educational tool, not just for improving academic performance but also for cultivating essential skills like digital literacy. Its broad application, from enhancing basic educational achievements to addressing specific needs in digital literacy and special education, marks it as an indispensable strategy in contemporary education.

10.2 Teaching using the Concept Mapping Strategy

Concept maps can be used as a methodological, educational, or instructional tool, as explained by Al-Sharbeni and Al-Tanawi (2001), Barenholz and Tamir (1992). They can also be used as a diagnostic tool to assess students or as an evaluative tool to evaluate what students have learned, as demonstrated by Novak and Gowin (1984), (Novak, 1990), (Mintzes et al., 2005).

Educators such as Qutami and Al-Rousan (2005), Safdar et al., (2008), and Hamdan (2023) have outlined the steps for constructing a concept map as follows:

1. Identify the topic or item for which the concept map will be drawn, which could be a text or a paragraph.
2. Determine the keywords through careful reading of the topic.
3. Identify the general concept around which the topic revolves.
4. Identify the sub-concepts of the main topic.

5. Prepare a list of the previous concepts and arrange them in descending order according to their generality and abstraction.
6. Draw the map by placing the concepts according to their generality, making sure to put each concept inside a shape (circle, square, rectangle, etc.).
7. Connect related concepts using lines, making sure to write the relationship between every two concepts above the line.
8. Support each concept with a short example, where possible.

Mawlid (2009) has presented a method for using concept maps in teaching as follows:

1. Concept Revelation: After assessing what students know about the concept, recalling their previous experiences about it, and correcting the errors that occur, the name of the concept and its definition are presented.
2. Concept Clarification and Explanation: Where the characteristics of the concept and its connections and relationships with other concepts are determined, considering the gradation from the general to the specific,
3. Concept Expansion: By helping students organize their ideas and apply what they have learned about the concept in other scientific subjects and daily life,
4. Concept Learning Evaluation: The evaluation process helps to show how well students understand the concept, and maps can also be used for this purpose.

Novak and Gowin (1984) mentioned several criteria that teachers can use to assess concept maps prepared by students. These criteria focus on the following aspects: relationships, which are valued at one point for each correct relationship between concepts; hierarchical organization, which is valued at five points for each correct hierarchical sequence; cross-links, which are valued at ten points for each correct and significant cross-link; and examples, which are valued at one point for each correct example. Additionally, Wallace and Mintzes (1990) built upon these criteria, though they allocated five points for each correct hierarchical level and ten points for each correct cross-link.

According to Coutinho (2014), teachers can assess concept maps by exploring answers to the following questions:

1. Does the map illustrate the meaning of the relationship between concepts through the connecting lines and linking words? One point is assigned for each clear meaning between concepts.
2. Does the map depict hierarchical organization? Is each concept more specific and more specialized than the concept above it? Five points are assigned for each correct hierarchical sequence.
3. Does the map demonstrate proper connections between different parts of the hierarchical sequence of concepts? Are the built relationships, correct? Ten points are given for each significant cross-link.
4. Additionally, one point is awarded for each event or action representing examples of the concepts. (European Union, 2018).

Upon reviewing various studies and research on concept maps, we find that the strategies for constructing these maps come in three forms:

1. Concept maps constructed collaboratively by the teacher and students during class sessions.
2. Concept maps built by students themselves.
3. Concept maps provided by the teacher as advanced organizers.

Okebukola (1992) showed that all ways of using the concept mapping strategy to help Jordanian students in the tenth grade solve math problems helped them do better and understand the concepts better. On the other hand, the study by Okebukola (1992) found no significant differences between students who used concept maps collectively and those who used them individually in developing problem-solving skills among a group of biology students. The study included a sample of 40 students divided equally into two groups, one control and the other experimental. The concept mapping strategy was employed through cooperative and self-directed learning to examine its impact on problem-solving skills. The experimental group achieved greater progress and success compared

to the control group.

In this study, concept maps have been classified into distinct categories by various educational researchers. Siaidi and Al-Balushi (2009). classified them into three types: hierarchical concept maps, clustered concept maps, and sequenced concept maps. Additionally, they introduced a fourth type known as spider concept maps. On the other hand, Al-Hammadine (2013) categorized concept maps based on their presentation to learners into four types: concept maps only, linking word maps only, virtual maps, and open maps.

In this research, several forms of concept maps were used while teaching the computer skills course, tailored to match the educational objectives, nature of the content, and learners' characteristics. These forms include:

- A) Hierarchical Concept Maps: Illustrating the relationship between concepts in a hierarchical manner, with the most general concept at the top of the hierarchy, followed by less general concepts and examples.
- B) Sequenced Concept Maps: Arranging concepts sequentially is important, especially when studying the computer's operation mechanism and data transfer between its parts.
- C) Clustered Concept Maps: Placing the most general concept in the middle of the map and surrounding it with less general concepts until the map is completed.

During the evaluation phase, whether formative, summative, or diagnostic, the following forms were used:

- A) Open Maps: Students were asked to create a concept map on a specific topic without adhering to a specific reference or predefined list of concepts.
- B) Virtual Maps: Students were presented with an incomplete concept map, including concepts, and linking words, and were asked to complete it based on their understanding.
- C) Linking Word Maps Only: Students were given an incomplete concept map containing linking words and spaces for writing the missing concepts. They were required to write the missing concepts.
- D) Concept Maps Only: Students were presented with an incomplete concept map containing concepts only, and they were asked to draw the appropriate links and write the relevant linking words. (Siaidi and Al-Balushi, 2009).

10.3 Positives and Negatives of the Concept Mapping Strategy:

The concept mapping strategy, like other strategies, has several positives, including adding enjoyment to the learning process and developing various thinking skills in students, particularly analysis and synthesis. It considers individual differences and encourages creativity, generating new ideas and perspectives. However, it also has its drawbacks, such as being challenging to read, especially when the topic involves multiple complex and interconnected concepts. Students may need practice, especially those who have not used it before. (Terry, 2001).

11. Results

There were tests to see if the following hypothesis was true: "There are statistically significant differences between the mean scores of the experimental and control groups in the post-application phase of the digital concepts test, with favor towards the experimental group." Table 1 presents the means, standard deviations, and t-test values for both independent groups.

After the concept mapping strategy was put into place, statistical analysis showed that the experimental and control groups got very different average scores on the digital concepts test. The experimental group, instructed using concept mapping, exhibited superior performance compared to the control group, which received traditional teaching methods. The significance level (p-value) of 0.05 indicates that these distinctions are not random but can be attributed to the influence of the concept mapping strategy on the students' comprehension of digital concepts.

Table1: Comparison of Digital Concepts Test Scores between Control and Experimental Groups

Group	Mean	Standard Deviation	t-value	Significance (p-value)
Control	7.884	0.000		
Experimental	13.371	4.215	21.314	0.000 ($p \leq 0.05$)

The results presented in Table 1 demonstrate significant statistical differences between the control and experimental groups in the post-application phase of the digital concepts test, with a clear advantage for the experimental group. The T-value for the experimental group was 7.884 at a significance level of 0.000, which is less than 0.05, confirming the validity of the alternative hypothesis.

The utilization of the concept mapping strategy in teaching digital concepts holds the potential to enhance students' comprehension and retention of the material, leading to improved test scores. This approach fosters critical thinking skills, the ability to analyze and connect concepts, and ultimately results in superior performance on the digital concepts test. Concept mapping accommodates diverse learning styles and cognitive abilities, enabling students to grasp the material more effectively. Furthermore, it nurtures creativity, encouraging the generation of new ideas and perspectives, ultimately facilitating a deeper understanding and application of digital concepts.

However, it is crucial to acknowledge that contextual factors like teaching strategies, student engagement, and subject complexity may have an impact on the efficacy of concept mapping. Nonetheless, incorporating concept mapping into the teaching of digital concepts can prove to be a beneficial and effective educational strategy, aligning with constructivist cognitive theory and fostering meaningful learning. Employing concept maps as summaries of key concepts and ideas presented in the course enhances students' retention and organization of knowledge.

Continuous feedback and reflection through concept mapping activities play a crucial role in correcting misconceptions and solidifying new cognitive structures. Allowing students to construct their concept maps promotes active learning and prevents a passive learning framework. Additionally, considering students' abilities and preferences when choosing between manual or electronic mapping methods enhances their engagement in the learning process. Incorporating colors and links into concept maps stimulates cognitive processes and aligns with how information is stored, facilitating efficient recall and comprehension.

Teaching students using the concept mapping strategy aids in the development of systemic thinking skills, which are highly relevant to computer skills, given that computers consist of multiple subsystems. Moreover, this strategy transforms the instructor-student interaction from traditional to multi-directional, positively impacting the development of digital concepts.

The findings of this study are consistent with those of the study by Qutami and Al-Rousan (2005).

12. Discussion

The results of the study provide valuable insights into the effectiveness of the concept mapping strategy in enhancing students' comprehension and performance on digital concepts (Alavi & Dufner, 2007; Baser & Yildirim, 2019; Novak & Caas, 2008; Ibok, 2020). The findings indicate that the experimental group, which received instruction using concept mapping, outperformed the control group taught through traditional methods (Alavi & Dufner, 2007; Ibok, 2020). This suggests that concept mapping has a positive impact on students' understanding of digital concepts (Alavi & Dufner, 2007; Shih & Chuang, 2013).

Several interpretations can be drawn from these results. Firstly, the use of concept mapping in teaching digital concepts may contribute to improved test scores (Baser & Yildirim, 2019; Novak & Caas, 2008). By visually representing the relationships between different concepts, concept maps help students organize and connect information in a meaningful way (Baser & Yildirim, 2019; Novak &

Caas, 2008). This aids in retaining the material and facilitates a deeper understanding of complex digital concepts (Alavi & Dufner, 2007; Novak & Caas, 2008).

Secondly, concept mapping encourages critical thinking skills and the ability to analyze and synthesize information (Shih & Chuang, 2013; Ibok, 2020). As students construct concept maps, they must identify key concepts and their interconnections, fostering higher-order thinking processes (Shih & Chuang, 2013; Ibok, 2020). This analytical approach likely contributes to the higher scores observed in the experimental group (Alavi & Dufner, 2007; Ibok, 2020). Moreover, concept mapping allows for the accommodation of individual differences in learning styles and cognitive abilities (Baser & Yildirim, 2019; Shih & Chuang, 2013). Students may have varied ways of processing information, and concept mapping provides a flexible framework that allows them to personalize their learning experience (Baser & Yildirim, 2019; Shih & Chuang, 2013). This adaptability may lead to better comprehension and engagement among students with diverse learning preferences (Baser & Yildirim, 2019; Ibok, 2020).

Additionally, concept mapping fosters creativity and the generation of new ideas and perspectives (Alavi & Dufner, 2007; Shih & Chuang, 2013). By encouraging students to actively participate in constructing their concept maps, the strategy stimulates their creativity and originality (Alavi & Dufner, 2007; Shih & Chuang, 2013). This creative engagement may contribute to a more profound understanding of digital concepts and their practical applications (Alavi & Dufner, 2007; Ibok, 2020).

In conclusion, the positive effects of the concept mapping strategy on students' test scores and comprehension show that it can be a useful educational strategy for teaching digital concepts. The findings from this study, along with previous research, highlight the significance of concept mapping as an effective tool for enhancing learning outcomes and promoting meaningful understanding of complex concepts. Educators can consider integrating concept mapping into their teaching practices to foster critical thinking, personalized learning experiences, and creative engagement among students. However, further research is warranted to explore the contextual factors and best practices for optimizing the benefits of concept mapping in various educational settings.

The success of concept mapping in enhancing students' comprehension and performance on digital concepts may depend on various factors, including the quality of instruction, student motivation, and the complexity of the subject matter (Alkhateeb & Alshraideh, 2016; Walters & Lawson, 2010). However, the significant differences observed in this study underscore the potential benefits of incorporating concept mapping into the teaching of digital concepts (Baser & Yildirim, 2019; Novak & Caas, 2008). The current study aligns with prior research that highlights the theoretical foundations and practical applications of concept maps in education (Novak & Caas, 2008; Okebukola, 1992). The strategy's grounding in constructivist cognitive theory, specifically advanced organizers, provides additional support for its efficacy in facilitating meaningful learning (Novak & Caas, 2008; Walters & Lawson, 2010). Furthermore, the study highlights the significance of accompanying activities when using the concept mapping strategy (Alkhateeb & Alshraideh, 2016). Reflection on the presented ideas and continuous feedback from instructors are essential for correcting misconceptions and reinforcing the connection between new and existing cognitive structures (Walters & Lawson, 2010; Okebukola, 1992). The study's practical application of concept mapping varied, with some maps created by teachers, others by students and teachers working together, and still others by students working alone (Novak & Caas, 2008; Walters & Lawson, 2010). This flexibility in approach allows for adaptation to different learning contexts and facilitates the personalization of learning experiences (Alkhateeb & Alshraideh, 2016; Baser & Yildirim, 2019). The study emphasizes the motivational aspect of concept mapping, as students' active participation in creating maps and receiving continuous evaluation positively impacts their motivation to learn (Alkhateeb & Alshraideh, 2016; Okebukola, 1992). Another noteworthy finding is that allowing students to construct their concept maps helps prevent them from falling into a demonstrative framework, promoting meaningful learning and the transfer of knowledge (Okebukola, 1992; Walters & Lawson, 2010). The strategic use of colors and links in concept maps aligns with brain function,

aiding in better recall and information organization (Novak & Caas, 2008; Walters & Lawson, 2010). This reinforces the idea that concept mapping aligns with the natural cognitive processes of the brain, making it a powerful learning tool (Alkhateeb & Alshraideh, 2016; Baser & Yildirim, 2019). Moreover, the concept mapping strategy fosters systemic thinking skills, which are particularly relevant to computer skills, where understanding systems and their components is crucial (Alkhateeb & Alshraideh, 2016; Walters & Lawson, 2010). Systemic thinking contributes to better information retrieval and long-term retention (Okebukola, 1992). Overall, the study's results suggest that concept mapping can be a valuable educational strategy for teaching digital concepts, contributing to better comprehension, critical thinking, and creativity among students (Baser & Yildirim, 2019; Walters & Lawson, 2010). As with any teaching approach, the successful implementation of concept mapping relies on proper training and ongoing support for instructors and students alike (Novak & Caas, 2008; Alkhateeb & Alshraideh, 2016). Further research can explore the applicability of concept mapping in various disciplines and educational settings, enhancing our understanding of its potential benefits and limitations (Baser & Yildirim, 2019; Okebukola, 1992). By strategically integrating concept mapping into the curriculum, educators can create an enriching and effective learning environment that promotes deeper understanding and meaningful learning experiences for their students (Walters & Lawson, 2010; Novak & Caas, 2008).

for making comparisons with existing literature: Putting our results in line with other academic research, this study supports the idea that concept mapping can help improve digital literacy. Our results echo those of similar studies, demonstrating significant improvements in students' ability to understand and apply digital concepts through concept mapping. Sinatra (2010) also highlights the utility of concept mapping in supporting literacy and learning, suggesting that it can serve as a formative assessment tool to enhance traditional literacy skills, including reading, writing, and technological literacy. Furthermore, our research contributes unique insights into its application within a digital literacy framework, particularly among university students with diverse academic backgrounds. This is especially important when you think about what Arslantas and Gok found in 2022 about the digital literacy skills of college students who are blind or have low vision. This demonstrates that a wide range of learners can use and adapt concept mapping. Unlike some studies that reported limited long-term retention, our preliminary findings suggest potential for sustained impact, warranting further investigation. This divergence underscores the need for continued exploration of pedagogical strategies tailored to digital literacy education, highlighting the importance of context in the application of concept mapping.

13. Conclusion

This research aimed to investigate the effectiveness of the concept mapping strategy in developing digital concepts among female students enrolled in the "Computer Skills" course at Prince Sattam bin Abdulaziz University in Al-Kharj. The study used an experimental quasi-design with 70 female students randomly assigned to either the control or experimental group, each comprising 35 students. The research question focused on the effectiveness of concept mapping in enhancing digital concepts among these students. The main objective was to reveal the impact of the concept mapping strategy on their understanding of digital concepts. After conducting a digital concepts test, statistically significant differences were found at the 0.05 level, favoring the experimental group, confirming the effectiveness of concept mapping in enhancing digital concepts among the female students in that group.

14. Study Limitations

The present study has several limitations that should be considered when interpreting the results. First, the sample size was relatively small, consisting of only 70 female students from the "Computer Skills" course at Prince Sattam bin Abdulaziz University in Al-Kharj Province. This limited sample

may affect the generalizability of the findings to other populations or educational settings, and caution should be exercised when applying the results to a broader context. Additionally, the study focused solely on female students, which may raise questions about the applicability of the concept mapping strategy to male students or mixed-gender groups. Future research with larger and more diverse samples would provide more robust insights into the strategy's effectiveness across different demographics.

Furthermore, external factors, such as students' prior knowledge, motivation, and individual learning preferences, were not entirely controlled in this study. These variables could have influenced the results and may account for some of the observed differences in test scores between the experimental and control groups. To minimize these potential confounding factors, future research could consider incorporating more comprehensive methods, such as the random assignment of participants to groups and controlling for prior knowledge through pre-test assessments. Despite these limitations, the study provides valuable insights into the effectiveness of concept mapping in enhancing digital concept comprehension among female students, laying the groundwork for future investigations in this field.

15. Future Directions

Moving forward, future research should address the study's limitations and explore new avenues to enhance our understanding of the concept mapping strategy's impact on digital concept comprehension. Firstly, studies with larger and more diverse participant samples, including both male and female students from various disciplines and educational backgrounds, would strengthen the generalizability of the findings. Conducting longitudinal studies over an extended period would also enable researchers to assess the long-term effects of concept mapping on students' learning outcomes and retention of digital concepts.

To gain a deeper understanding of students' learning experiences and perceptions related to concept mapping, a mixed-methods approach could be employed, combining quantitative data from tests with qualitative data obtained through interviews or surveys. This approach would provide a comprehensive view of the strategy's effectiveness and its impact on students' cognitive processes and critical thinking skills.

Concept mapping could also be compared to other active learning strategies in the future, like problem-based learning or group discussions, to see how well it works for understanding digital concepts. Implementing classroom observations could offer valuable insights into how instructors use the concept mapping strategy and its influence on students' engagement and learning outcomes.

Exploring the potential benefits and limitations of digital concept mapping tools compared to traditional pen-and-paper methods would be an interesting area for future investigation, considering the increasing use of technology in educational settings. Moreover, assessing the impact of concept mapping on diverse cognitive skills, such as systemic thinking and information processing, can provide a deeper understanding of its underlying mechanisms.

In conclusion, by addressing these future directions and conducting rigorous research, educators and researchers can continue to advance our knowledge of the concept mapping strategy's effectiveness in teaching digital concepts. This knowledge can inform instructional practices and contribute to creating more effective and engaging learning environments for students.

16. Study Implications

- A) Concept mapping in academic courses, particularly computer skills or digital technology courses, enhances students' comprehension and performance on digital concepts, encouraging educators and institutions to adopt this strategy in their teaching practices.
- B) Students should receive training on using concept mapping effectively in various fields, empowering them to create meaningful representations of knowledge through concept

maps.

- C) Educators at all educational levels are encouraged to actively implement concept mapping in classroom activities and assessments, fostering critical thinking, creativity, and deeper understanding among students.
- D) Concept mapping aligns with constructivist cognitive theory and advanced organizers, facilitating meaningful learning by connecting new information to existing cognitive structures.
- E) When using concept mapping, activities that go along with it and constant feedback help correct misconceptions and strengthen connections between new and old cognitive structures, which leads to better learning outcomes.

17. Recommendations

Based on the research findings, the study recommends the following:

- 1. Encourage educators at all levels to implement the concept mapping strategy, which has proven effective in enhancing students' understanding and retention of concepts.
- 2. Use concept maps as personalized, instructional, or assessment tools tailored to different teaching stages, educational objectives, and learner characteristics.
- 3. Provide training workshops for faculty and teachers to effectively integrate concept mapping into their teaching methodologies.
- 4. Raise student awareness about the benefits and applications of concept mapping in various fields of study, encouraging them to use it as a valuable learning tool.
- 5. Train students on creating concept maps and differentiate them from other visual representations to ensure meaningful and coherent maps.

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