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The Impact of Concept Mapping as a Learning Tool in Teaching of Mathematics

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Abstract

Numerous researchers have studied the idea of mapping the learning strategy in mathematics teaching and learning. There are, however, still fewer researchers who have explored the functions of the idea of maps that are relevant to mathematics teaching. The definition map is also used in adaptive learning environments to provide teachers with further review and improvement of teaching methods and generate adaptive learning guidance. It will assist learners in comparing one concept to another concept to solve mathematical problems faced by the student, being well recognised on the map concept. The investigation's main objective is to demonstrate the use of concept maps to facilitate effective mathematics teaching. The research findings are: 1) the mathematical comprehension skill of students has reached the category of reasonable enough level; 2) the mathematical comprehension ability of students who have taught learning strategy of concept mapping is greater than those who have taught traditional learning strategy. From the findings, it may be decided that the concept mapping strategy for learning could increase learners' ability to understand mathematics.

Keywords: Concept Map; LearningStrategy; Mathematics; Teaching of Mathematics; Mathematics understanding ability.

Introduction

The new educational model places extra importance on students as human beings who have the ability to discover and grow. In the quest and creation of information, students must be involved. The truth of science is not restricted to what the teachers present, although also to becoming facilitators who direct learners on their own towards the creation of knowledge. By the new approach in the classroom, learners are interested in learning, debating, expressing thoughts, embracing other ideas, and seeking the best answer to any high trust problems [1].

Mathematics (maths) is considered as the backbone of all the subjects. So, every mathematics requires teaching their student with the proper strategy, which led them to gain suitable knowledge of the subject. The basic of every subject is essential, so as in mathematics if the teacher teaches the basics of mathematics perfectly, it will surely help students learn better. Many factors influence the students' accomplishment in which the strategies of teacher are essential.

The subjects Mathematics has played a very significant part in studying together with direct object facts, basics, ethics, principles and an indirect object like crucial attitude, analytical and rigorous in demand to make the better condition of teaching, specifically to upgrade their mastery of science. Observing the significance of maths, it is a very mandatory subject for being taught in primary school up to high school. Most of the time, teachers find students who cannot solve the mathematical problem due to the absence of a basic and suitable strategy that has not been taught before.

There are many causes regarding this: one of them is that the student's ability is deficient. He cannot correlate mathematical problems with mathematical ideas because these learners do not grasp the concept of mathematics. In the procedure to learn mathematics, the concept taught earlier will be useful for learning new concepts. After considering this, Hudojo said, "someone learning becomes easier because their learning is centred on what the students have already understood". To understand a

Modern concept in mathematics, previous learning, and experiences from somebody will influence understanding the math material [2].

Understanding many chapters in mathematics such as Trigonometry does not need only to be anxious with the result but also have to give more thought to its method. By learning trigonometry, the students may also increase their capability in linking earlier concepts to additional concepts such as cosine, sine, angle, tangent, graph, and function. Hence, it may be believed that the concepts of every mathematics chapter are connected to further chapter. The connection of inter topic in maths, maths with other disciplines and maths to daily life is known as Mathematical connections (MCs). The MC's capability is also a mathematical power that should be grown in understanding mathematics in school life. The MC's capability is directly related to the strength of the learners to compare or MCs to the additional concepts in mathematics, mathematics in various specialities, and daily life mathematics. As stated by Mikovch and Monroe, there are 3 MCs, that are:

1. The connection and relationship in mathematics
2. Connection with the real world
3. Curriculum connection

Kutz disclosed that the connection of mathematics is associated with the external connection and internal connection. Internal connection comprised inter-topic topics, whereas external connection comprised additional disciplines and connection with daily life. Riesdel explains the MCs into 5 kinds of knowledge:

1. Inter topic connection in mathematics
2. The connection among certain kinds of knowledge
3. Connection for the representation among several kids
4. Establish a connection between mathematics and other curriculum areas
5. Establish a connection with students [3].

Based on standard MC, the level of KG to 12th as per the NCTM is as given below:

1. Observe and utilize the connection between mathematical concepts.
2. Acknowledge in what way mathematical idea connection and construct on one another to the developed rational whole.
3. Observed and implement mathematics in situations beyond mathematics [4].

Referring to some of the above opinions, it could be summarised that certain features indicate that a student has the potential to have mathematical links, which is that they can recognize and use the relationship between the math concept, students often understand that math concepts associate to each other and convert completely unified and integrated. Students were also proficient to know and utilize the usage of mathematics in their daily lives. The poor mathematical relation capacity caused by many factors when learning mathematics is because students cannot connect the mathematical concepts that have been studied and the mathematical concepts that are being taught. This occurs because without attempting to interpret the ideas, students can frequently memorize mathematical ideas.

Learning is said to be relevant, according to Ausubel, if the knowledge learned by learners is made in harmony with the mental framework so that students can easily achieve good memory and learning transfer [5]. Another element of students' ownership is that they have a reasonable approach to integrating math concepts with others and can be implemented in real situations. First, the concept mapping approach is a strategy to use a deviceknown as a concept map to learn and accomplish learning goals. It is also characterizedlike a 2D map composed of concepts indicating nodes and labelled lines indicating the relationships among node pairs [6].

Concept mapping technique for learning will assist learners in their learning. Sufficient knowledge of the connection and interactions among concepts and additional concepts related to the learning technique of concept mapping will significantly help students solve difficulties in mathematics learning. Study in secondary [17][29] and university mathematics showed that after a semester of concept mapping [30][31][32][7], students' conceptual comprehension of mapped topics was more improved. In line with earlier studies, Nwoke, et al. noticed that the concept mapping technique substantially increased students' performance in mathematics than conventional techniques, had no gender impact, and promoted students' involvement and interest in the classroom [8].

Concept Maps (CMs)

CMs are graphical tools for information organisation as well as representation. They involve concepts, typically confined in circles or boxes of various kind and associations among concepts marked by a connecting line that connects 2 concepts. Words on the line define the relation between the two concepts, stated as connecting phrases or connecting words. The mark is a term for most terms, but we often use symbols like + or % and multiple words, are utilised sometimes. Propositions are statements, either naturally occurring or invented, about some entity or occurrence in the universe.

Propositions include two or more ideas linked to form a coherent argument by connecting words or phrases. These are also termed semantic units, or sense units. An illustration of a CMwhich explains the composition of CMs is shown in Figure 1 and demonstrates the features above. An Additional aspect of the CM is that the concepts are described with the highlywide-ranging, more broad concepts at the map's top and the additionalprecise, less general concepts organised hierarchically below in a classified fashion. Instead Of a specific knowledge area, the hierarchical structure often differs on the sense in which that knowledge is used or believed.

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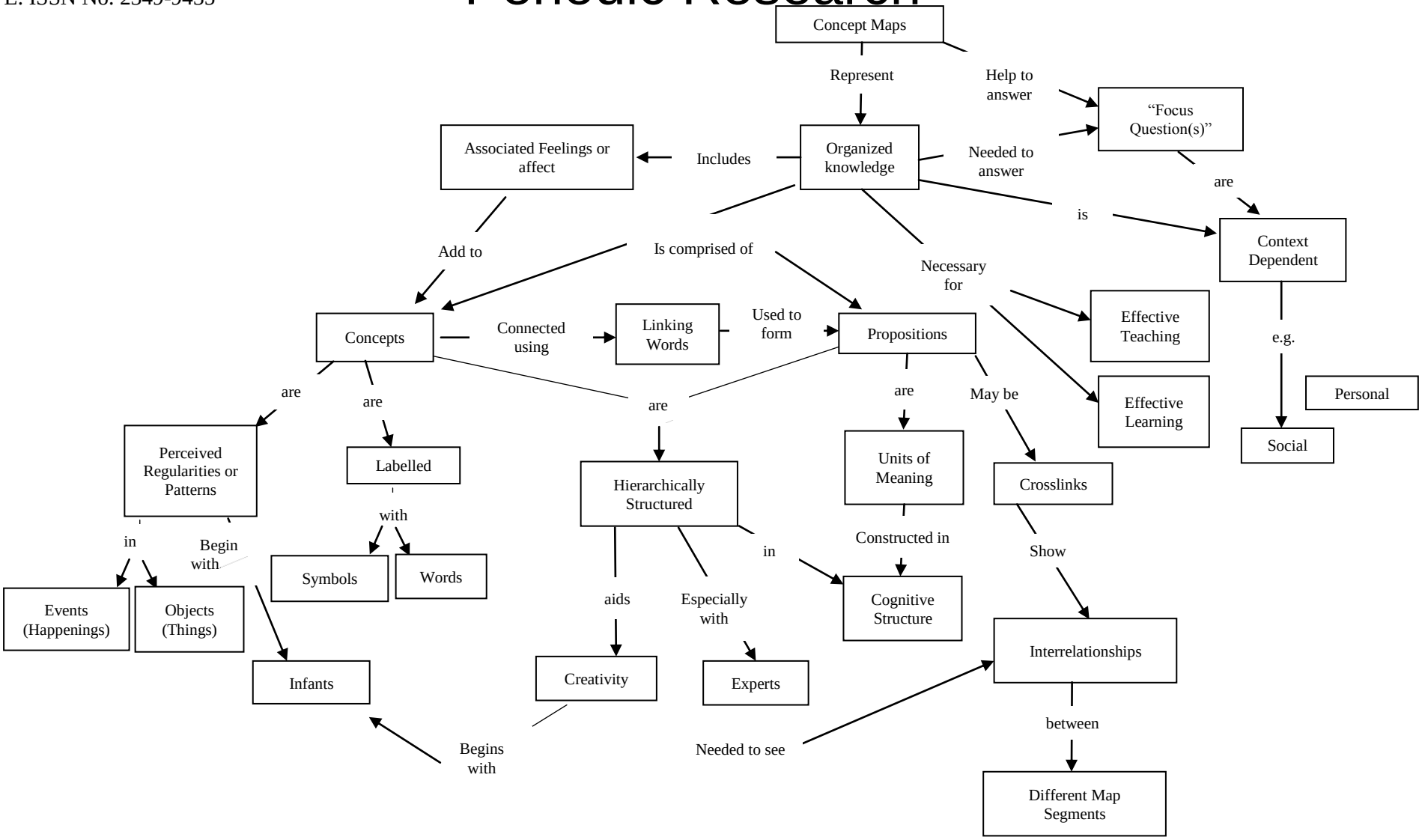

Fig. 1.: A concept map showing the key features of concept maps. Concept maps tend to be read progressing from the top downward [9]

Thus, it is better to create CMs concerning certain specific question we are trying to address, which we have termed a focus question. The CM can relate to various conditions or events we are attempting to explain in the form of a CM through the organisation of information, thereby offering the CM context. The use of cross-links is another significant feature of the definition map. These are relationships or connections among concepts in the CM's various segments or domains.

Cross-links enable us to find out how a concept is linked to a concept in a new area seen on the map in one area of information defined on the map. Cross-links also reflect imaginative leaps on the part of the information creator in the development of new knowledge. In the facilitation of creative thinking, there are 2 important characteristics of CMs: the hierarchical structure reflected in a good map and the capacity to explore for and characterise new cross-links. Clear cases of events or artefacts helping to explain the significance of a provided concept are a final function which can be applied to CMs. These are typically not confined in boxes or ovals because they are individual events or objects and do not show ideas [9].

In 1972, during Novak's research programme at Cornell, CMs were created where he tried to pursue and figure out improvements in kid's understanding of science [10]. The scholars interviewed several children during this study. They discovered it hard to distinguish clear improvements in the comprehension of science concepts by children by analysing interview transcripts. This programme was focused on David Ausubel's learning psychology [11][12][13]. Their early research using mathematical CMs concentrated on showing how mathematical concepts can be characterized in this form.

Cardemone [14] illustrated how the main concepts could be interpreted using CMs in a remedial college math course. He discovered that the usage of CMs could assist teachers in constructing an improved sequence of subjects and help students see connections among subjects. Minemier [15] discovered that when students created CMs for the subjects, they studied that they did well on problem-solving assessments and achieved greater faith in their capability to do maths. In Western Samoa, Fuata'i [16][17] used CMs together with vee diagrams with Type 5 learners. She found that students were further independent students and better at solving novel difficulties relative to students not using these resources.

Psychological Foundations of CMs

Often issue emerges as to the roots of our initial notions, developed by kids between the birth and 3 years of age after uniformities in the world across them are known, and language labels or symbols for these uniformities are identified [18]. This initial concept's learning is mainly a learning phase of exploration. The person perceives patterns or uniformities in events or items and identifies them as the same uniformities identified with older people's words or symbols. This is a great talent that is a component of all common human's evolutionary heritage.

New concept and propositional learning is deeply influenced by language after age 3 and happens mainly through a reception learning process. Different significances are acquired by asking questions and clarifying the relations among propositions & old concepts and propositions & new concepts. When concrete interactions or props are available, this acquisition is mediated in an extremely significant manner; therefore, the value of "pro-active" practice for science learning with young children, although that is also valid for students of any age and in any area of the subject matter.

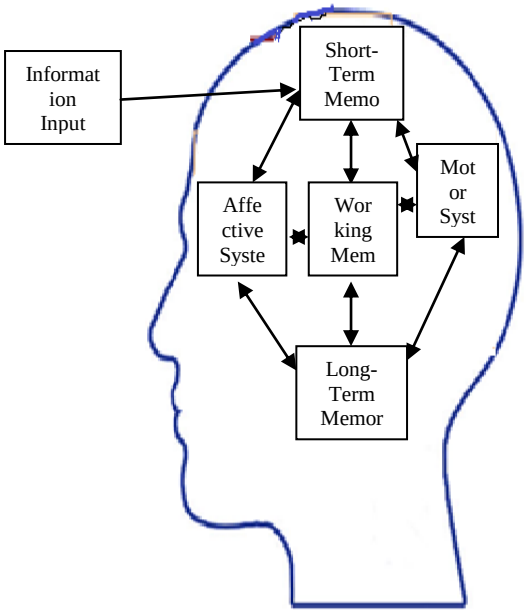

Fig. 2.: Key memory systems of the brain all interact when we are learning [9].

Not only as a learning mechanism, although as well as an assessment tool, one of the strong uses of idea maps allows students to use practical learning patterns [19][20][21]. In recognizing together true and invalid ideas held by learners, CMs are also useful, and this will be discussed further in another section. Before or after instruction, they may be as successful as more time-consuming clinical interviews to determine the applicable skills [22]. Another major development in understanding learning is that our memory is a dynamic collection of interrelated memory structures rather than a single "vessel" to be filled. The memory mechanisms of the human mind and experiences through stimuli from psychomotor and affective inputs are shown in Figure 2. Although several learners indeed have trouble creating and utilising concept charts, at least early in their understanding, this seems to arise largely after years of rote-mode learning practice in school environments instead of variations in brain structure per se. It is not simple to support learners' transition to learning of the latter kind in the former situation. Although CMs can assist, something about brain structures and information organisation must also be taught to

students, and this guidance must accompany the usage of CMs. Ideas for enhancing teaching are available elsewhere to gain an understanding of the subject [23].

Epistemological Foundations of Concept Maps:

Epistemology is the philosophical branch which deals with the essence of information and the development of new knowledge. As we understand it today, there is a significant link between the psychology of learning and the increasing agreement between epistemologists and philosophers that the development of new knowledge is a positive procedure, including knowledge and feelings, or the determination to develop new methods representing these meanings. At best, rote learning adds little to knowledge systems and does not underlie innovative thought or the resolution of new problems.

Concepts and ideas in every domain are the building blocks for information. There are about a hundred different types of atoms. Also, an infinite number of various types of molecules are made up of them. As individuals make and experience new or current artefacts or incidents, new ideas and new information will continue to be generated by creative people. Typically, introducing new ways of monitoring or documenting events opens new possibilities for developing new information. The invention of the concept mapping method for documenting the understandings of topics, for example, has led to new opportunities for researching the learning process and new knowledge creation [6].

Constructing Good Concept Maps:

It is necessary to start through a field of understandingwhich is extremelyrecognisable to individual building map while learning to create a concept map. Since CM structures depend on the situation in that they will be utilized, it is better to define a section of a document, a lab or field operation, or a specific challenge or query. This provides a sense that will assist in evaluating the concept map's hierarchical structure. For the first idea maps, it is beneficial to pick a small area of information.

Each CM reacts to a question of focus, and a good question of focus will lead to a much stronger CM. Learners tend to deviate from the focus question when learning to construct CMs and generate a CM that might be relevant to the domain but does not address the question. It is also mentioned that asking the correct questions is the first step to learning about something.

The subsequentstage is to recognise the important concepts that apply to this domain, provided a particular domain and a specified question or issue in this domain. Fifteen to twenty-five definitions will typically suffice. These concepts should be listed, and then a rank-ordered list from the most general, most inclusive definition, to the most unique, least general concept at the bottom of the list, for this particular problem or situation at the top of the list, could be created from the list.

We refer to the list of concepts as a parking lot because we will transfer these concepts into the CM as we decide where they fit in. It is necessary to understand that a design map is never completed. It is constantly important to modify this map after a preliminary map is built. It is possible to incorporate other definitions. From three to several revisions, good maps generally result.

Cross-links should be sought until the preliminary map is constructed. There are relations between concepts on the map in various segments or domains of information that explain how these domains are connected. It is essential to assist students to understand that all concepts are connected in some way. Therefore, in identifying cross-links, it is important to be selective and be as accurate as possible to find linking terms that link concepts.

Furthermore, "sentences in the boxes" must be avoided, i.e., complete sentences used as definitions, as this typically means that a whole subsection of the map may be created from the box argument. Once students start focusing on good linking terms and finding good cross-links, they may see that every notion can be connected to every other notion. This also causes some rage; besides, they need to consider the highly common and extremely beneficial cross-links.

This phase includes what Bloom [24] described as high cognitive performance levels, specifically information assessment and synthesis. When the procedure is well performed, concept mapping is a simple way to promote very high levels of cognitive efficiency. This is one reason why mapping the definition may also be an advantageous method for assessment [25]. Finally, the map should be updated, ideas re-positioned, and a "final" map prepared in ways that offer consistency and better overall structure. Thus, we observe that CMs are a powerful tool for individuals' information to be captured, interpreted, and archived and a powerful tool for generating new knowledge.

Uses of concept mapping in mathematics education

In several applications, CMs were found to help teach various sciences although similarly maths at all levels, varying from primary school to senior high school. In the following cases, CMs, for example, can be used [20][21][39][40]:

CMs assist in managing data on a subject

Information must be structured to promote comprehension and problem-solving capacity to be useful. In order to be quickly remembered and retrieved, a definition map organizes information into categories and sub-categories.

Concept maps promote practical learning, help coordinate new topics and understand them

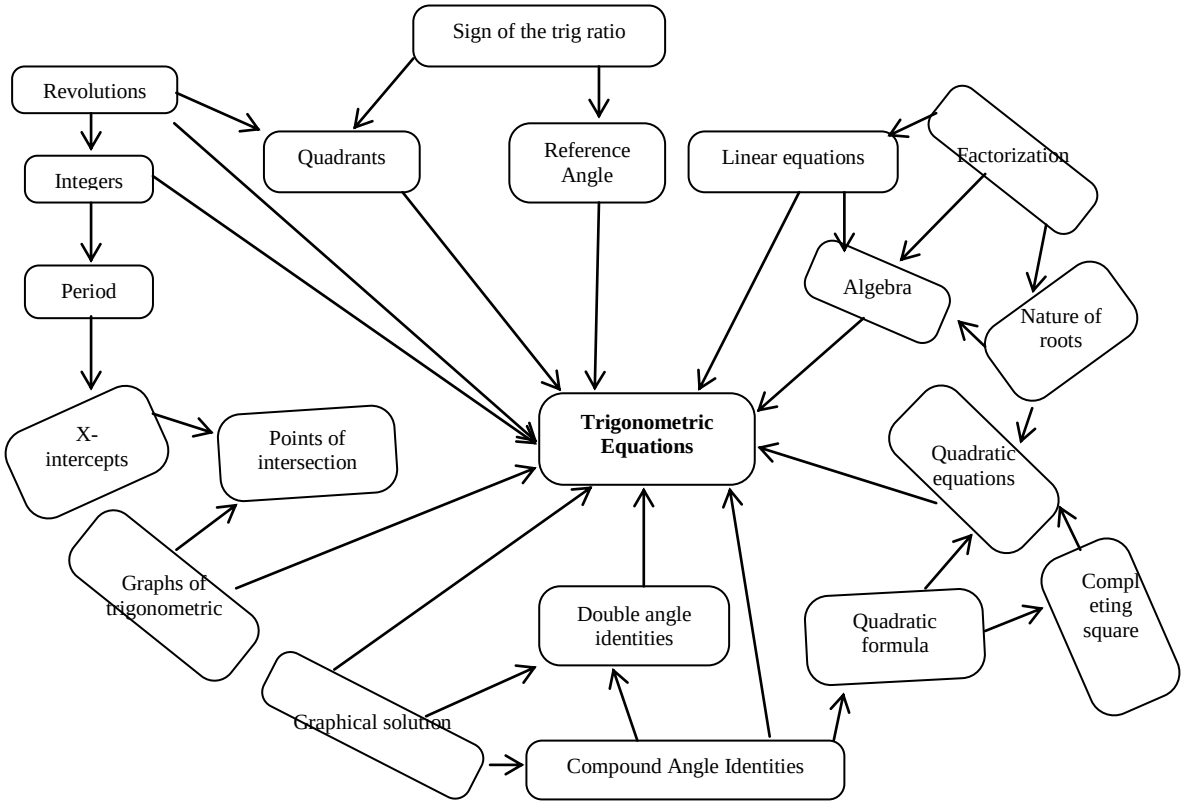

Fig. 3: Concept map for solving trigonometric equations [42].

CMs are an effective tool for recognizing the knowledge structures of students, particularly misunderstandings or alternative conceptions

By considering what a learner already knows, this allows the instructor to prepare successful lessons. Students themselves acquire information about their own organization of knowledge. Possible incorrect relations in the student's information become clear to the instructor and could be changed by him or her.

CMs assist in training the brain. CMs can act as a memory aid. Since a CM is a graph, a pictorial representation, it can be understood at once and committed well to one's memory and recalled faster due to its specific appearance.

CMs can be utilized to revise a topic

A CM may be created as a repeat at the end of a topic and obtain a permanent and well-organized summary of a topic.

For the design of instructional materials, CMs could be used

Teachers realized that CMs were helpful tools for planning a lecture or a whole curriculum. Besides, they assisted in preparing training and improved their own comprehension of the matter of subject [39].

Concept mapping may enhance attitudes towards mathematics

By way of CMs, an individual's mathematical awareness can acquire more structure and consistency. The perspective of the individual on mathematics might become more optimistic. Also, CMs help students understand that math is not a set of independent regulations and data through their visualization. However, a web of concepts in that every concept is linked to many others. The authors of the Curriculum and Evaluation Standards for School Mathematics "insist that the formation of connections between mathematical concepts helps learners to acknowledge the subject's beauty and power" [41]. Thus, concept mapping can lead to a shift in a person's beliefs about mathematics, giving them a more optimistic emotional load.

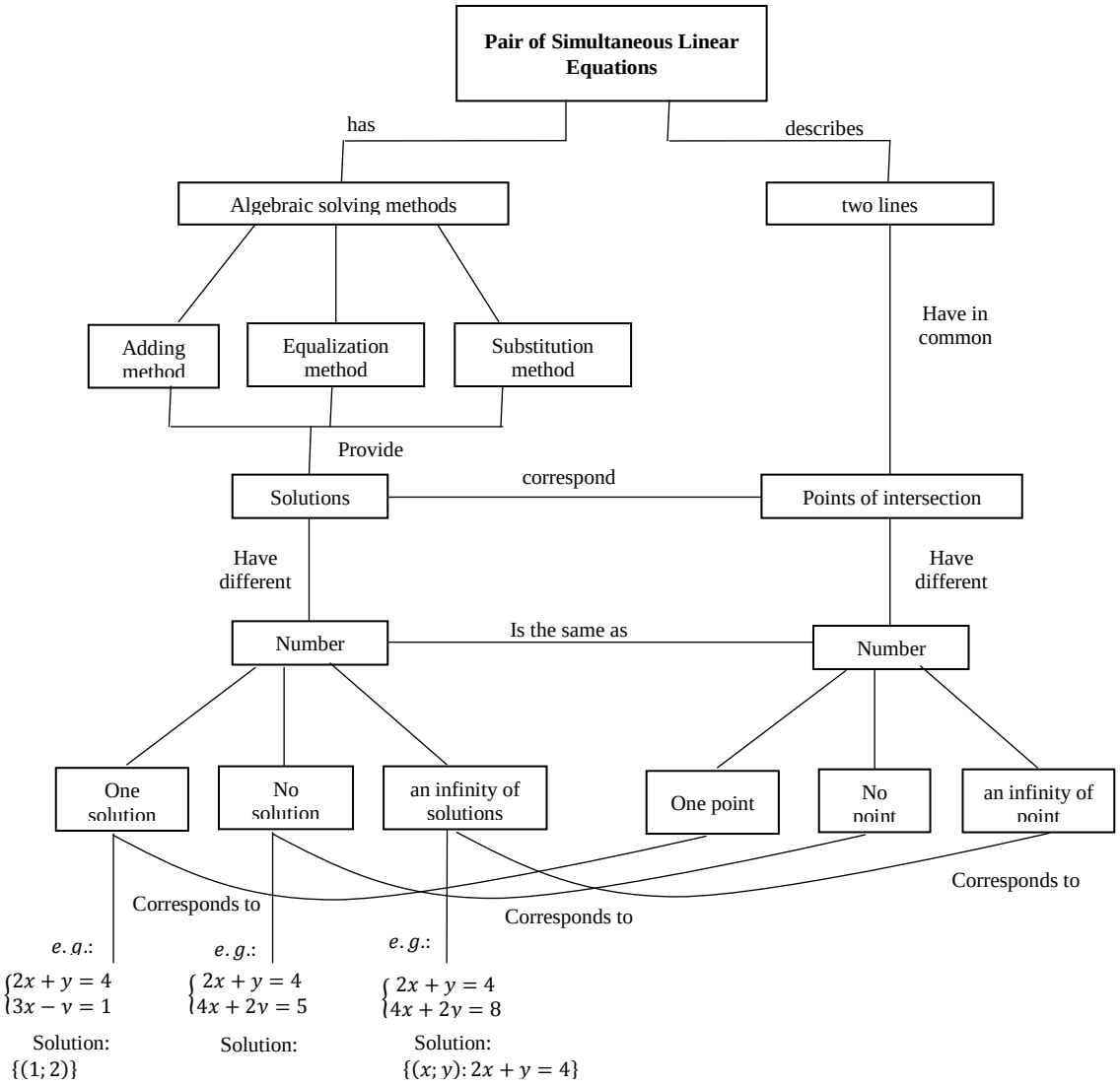

Fig. 4: CM on the topic of linear equations [43]

Review of Literature

As per the Novak and Gowin theory, CMs are depicted in boxes and circles are connected by tagged arrows in a downward branching heretical manner. When the concept map is well organized in an ordered framework, the most essential and more extensive concepts must be in starting the concept map, with consistently more particular arranged below them.

According to Novak and Canas [9], CMs are also a graphical representation tool for constructing and organizing knowledge. Commonly circumscribe in a circle or boxes of certain kind and connection among the concepts point out through a connecting line joining 2 concepts. Those words on the line known as connecting words or connecting phrases described the connection among the 2 concepts.

In 1972, the CM was first coming into existence at Cornell University by Novak. Further, in 1979, in "American Biology teacher" Stewart, Van Kirk and Rowell [26] claimed that they are the first originators of CMs. However, in their CMs, there was the absence of links and propositions. After some time, in a similar journal, Novak published two articles to provide Stewart's credentials. He also gave examples of some CMs nut again there was no connection between links and linking phrases. Nonetheless, Novak and Musonda established the linking phrases and meaningful proposition in his concepts.

In 1998, Novak applied "Concept Map TM" as a brand name of his concept mapping style. Nonetheless, his analysis partners and students didn't follow the guidelines made by him for concept mapping. Also, Novak himself doesn't keep his own principles [27]. Similarly, Wandersee opposed one of Novak's book figures because the CM he made on rhizo botany did not follow the Novakian Standard Concept Mapping Format.

Adaramola [28] presented thought concerning cyclic CMs that are defined. This winds up in the introduction of CMs in any manner that should

be explained. The reason behind this is that as per modern science, the system of the world and everything on the planet is associated with each other. That is why a CMs can be interrupted as a temporary hypothesis of an aspect of the world.

Ausubel made a genuine effort to introduce guidance or information in the proper concept map form. This technique would also be utilized to organize one's thoughts on paper expediently and straightforwardly. In Ausubel's subsumption hypothesis, he affirmed that "the highly extreme significant component that affects learning is what the past information that learner has. The subsumption hypothesis's main process is the connection of new material to ideas in the current psychological structures. Ausubel also proposed that the utilization of advance coordinator as an essential educational mode. He laid more stress on the advance, coordinators that these are unique in generalization and briefs. The organizers' function as a "subsuming bridge" between new learning material and previous knowledge and thoughts.

Professor Joseph D. Novak explained the Ausubel hypothesis. In the end, as per the Novak, "Meaningful learning includes absorption of fresh ideas and recommendation towards current cognitive framework", however, Novak practised Ausubel hypothesis into concept map structure which is comprised of central nodes ideas and connections phrases and remarks. As per the analysis of Hafiz *et al.* [33], the CM learning method in teaching and studying maths has been inspected by various experts. Nonetheless, there are very few experts who have verified the roles of CM associated with the mathematical connection potential.

Concept mapping may assist students who can solve the entire mathematical problem they encountered. This investigation aimed to explain the students' mathematical connection ability and examine the influence of using CM learning method to the learners' mathematical association capability. This analysis was performed at senior high school in Jakarta. This method utilized about 70 students as a sample. By using the test, data obtained in the post-test after providing the care. The outcomes of the research are:

1. Mathematical concept connection of students has attained a great sufficient level.
2. Mathematical concept connection of students who taught with the concept mapping learning method is greater than who had taught with the regular learning method.

According to the theory proposed by Devčić et al. [34], CMs are considered as the graphical tools for creating and showing knowledge. Utilization of CMs is the modern method of work that still has not shown a suitable place in teaching methods. We always recognize that teachers should be started some modern way of teaching by using all these processes. In this review, we explain the CMs and their use of mathematics learning, teaching and informative assessment.

As per the Bolte [35] study, the building if the CMs in mathematics courses offers students a high learning method and experience and gain a suitable view into the range of association their knowledge to some topics. Some of the students are given a chance to show their ability and knowledge that creates sense to them, examining the concept, and maps offer the teachers with worthy knowledge about ones and whole class misunderstanding and the guidelines' productivity. This review explains how CMs may be utilized in different mathematics courses to classify the modern concept of students in terms of the Van Hiele standards.

As per the Gonzalez *et al.* [36] research, CMs considered as a pedagogical tool for attaining actual learning in medical physiology students. Also, as per the explanation of Gonzalez *et al.* [36], the pedagogical tool as a metacognitive method helps students grow a self-investigation of their personal reasonable processes. They categorized the students in the 2:1 ratio of intervention students to handle learners. There are two types of students given to students; there was also a multiple-choice question test where learners had to memorize past information and problem-solving tests where students have to solve the particular question using a hierarchical framework option.

Qualitative examination shows that intervention enhances the students' inspiration and increases active participation in the building of individual knowledge. Outcomes showed that the intervention unit of students performed better than the control group (CG). In the line of Interviews in my examination where students would be expected to rectify their connection. CMs are very useful for giving meaning full and actual learning in medical students. As per the study conducted by Grevholm [37], a deep research on the CMs in mathematics learning. Conce beneficial the basic and concepts growth of the students in mathematics. This analysis comprised 48 students' teachers ready to teach ion school years 4-9 in Kristianstad University in Sweden. She also gathered some data through question and interviews.

Outcomes failed the researcher to occupy an image of the solving of the students of their self-learning. Since the CMs half been introduced among the students, Grevholm utilized these CMs as an optional method to gather data. Here students need to outline the CMs on 3 different events over a time span of 15 months. Grevholm examined 3 CMs of first students. That map is different in the complication in the present development of the understanding concept of students. She also determines that CMs gave a high-grade material and appropriate knowledge about how the students convey their mental framework become accessible. Moreover, Grevholm determines that CMs gave multidimensional responses than linear responses in the form of a line. Therefore, CMs may be very efficiently utilized as a research tool.

Olanrewaju and Friday [38] explored the impacts of CM Approach on student's accomplishment and retention in Mathematics of senior secondary school two students in Ekiti State, Nigeria. The design for this examination was Pretest-Posttest Quasi-Experimental. The populace for the

investigation was all the senior secondary class two (SS2) mathematics students in Ado Local Government Area of Ekiti State, Nigeria. The sample contained fifty (50) students each chose from every one of the two co-educational secondary schools in Ado-Ekiti city to make a sum of (100) SS2 students. One of the schools was casually chosen for the exploratory gathering but the other assigned for the CG. The test group was taught utilizing Concept-mapping method while the CG was taught utilizing the regular technique.

Three null theories were planned and tested at 0.05 degree of importance to control the study. The instrument for information gathering was forty (40) normalized objective query tagged: Mathematics Achievement Test (MAT). The information gathered was investigated utilizing the t-test statistical examination. The discoveries indicated that: in the pre-test, the acquired mean scores are not altogether quite the same as another, which demonstrated that the two gatherings chose are homogeneous.

Additionally, the acquire retentive-test mean score of the exploratory gathering was altogether greater than the retentive-test mean scores of the CG. The discoveries uncovered that students in concept mapping system groups performed fundamentally in a better way than their partner of traditional technique. It was suggested that mathematics teachers ought to notify their students on the utilization of the concept mapping methodology and urge them to investigate the technique in their problem-solving capacity.

Research Method

Research Design

This analysis utilized the techniques of descriptive analysis. For the conduct of statistical studies, descriptive analysis is a significant first step. It offers us an understanding of our observations' distribution, helps us recognise outliers and typos, and enables us to identify the associations of variables, allowing you prepared to do further statistical analyses. This is the techniques that are used to explain the influence of globalization on teamwork in business.

Data Collection Strategy

Initially, the information was gathered with the assistance of a survey by contributing self-administered to examine the question to explain globalisation's influence on teamwork in business. The secondary data was gathered via journals, websites, books, magazines etc., on the influence of globalization on working as a business team.

Pilot Study

This study was used to check and identify the research instruments that have been utilized in the survey. For completing the Pilot study, the link to the poll was imparted with approx. 50-60 people. The pilot expectation increased the poll levels and assisted in evaluating the sample size used in this study.

Analysis of Data

SPSS (Statistical Package for the social sciences) is the package utilized to complete the statistical analysis. SPSS is software for all types of data editing and analytics. Essentially, this information may arise from any cause: statistical analysis, a consumer database or even a website's server log files.

Sampling

Non-anticipated sampling method was utilized to collect the responses from the members. The self-administered question was distributed and demanded that users participate in the survey via Facebook, social media, email, Twitter, WhatsApp. The members were also asked to impart the poll link to their associated networks to collect more data.

Sample Size

The sample size for the study was 200 respondents.

Tools Used

For study purpose, various tools were used to examine the data gathered via poll. A descriptive analysis, like mean and standard deviation, was utilized for the compression of large data. Various kinds of charts were used for the graph of data and information. Various parametric and nonparametric examinations such as the Chi-square test, regression, and ANOVA test were also utilized to test various theories of the analysis.

Results and Discussion

Many respondents acknowledged that CMs were beneficial in improving their comprehension of and applying mathematical principles but thought that CMs did not help improve these concepts' application to problem-solving. Experiences that were contradictory to these general themes offered insight into how definition mapping could be more efficiently applied, taking into account their mathematics anxiety and their experiences as adult learners to connect learners' personal requirements.

To reflect their evolving knowledge of introductory mathematical concepts, students created a succession of CMs throughout the term. In several ways, participants witnessed the usage of CM for learning introductory mathematics. The use of concept mapping strengthened some participants' learning, impaired others' learning, and left no significant impact on others. As adult learners, their perspectives were primarily intertwined with their features.

Typical features of adult learners that may have affected their concept mapping experience include their previous mathematics learning experiences, their learned research patterns and methods, their problem-centred learning orientation, their perceived importance of concept mapping to their mathematics learning, and time constraints. The effect of concept mapping on impact was also multifaceted and was embedded in initial mathematical feelings and preconceptions.

A greater capacity to grasp and describe essential mathematical concepts was perceived and demonstrated by some students. A majority perceived that their ability to connect and link mathematical ideas influenced concept mapping's relational frameworks. However, most did not perceive the influence of concept mapping on applying problem-solving or data analysis mathematical concepts. The following are the findings relevant to these research questions:

Students' Experience Using Concept Mapping to Learn Mathematics

Serial Number	Perceptions	%
1.	Concept mapping assisted me in learningmathematics.	97
2.	Concept mapping helped me integrate and clarify the interrelationships among curriculum contents.	97
3.	Concept mapping learning strategy stimulated me to learn and think independently.	95
4.	Concept mapping helped me reduce the barriers and enhance my interest in learning mathematics.	89
5.	Concept mapping can be a new mathematics teaching and learning approach.	95
6.	I think the concept mapping strategy can be easily used in other curricula.	95
7.	I will consider using the concept mapping learning strategy in other curricula.	95
8.	I was satisfied with using concept mapping in learning mathematics.	90
9.	I liked using concept mapping to assist me in learning mathematics.	84
10.	I may easily be adapted to concept mapping,	58

Positive Aspects of Experience

By the use of concept mapping, students experience an enhanced awareness of mathematical concepts. Some participants thought that by collaboratively constructing the charts, a fuller and more productive experience with concept mapping could have been achieved. The findings indicate that those students who responded well to the usage of CM in the course may have experienced more advantages than those who did not use the technique comfortably. Some of the students who were found to be comfortable with the concept mapping methodology, as demonstrated by the discussion of their previous and current experiences with concept mapping and the complexity of their CMs, suggested that CMs helped their ability to understand mathematical concepts and to connect mathematical ideas.

Negative Aspects of Experience

The use of concept mapping in the study negatively affected some students. Within and outside the study space, students shared views of concept mapping as a waste of time. Some students have found concept mapping in dissonance with their learning style, study patterns, or time constraints. These students also displayed student resistance in some way. Furthermore, some students have searched for ways to make concept mapping important to their daily or educational lives. Some (though not all have preferred to concentrate on problem-solving techniques that may or may not have involved concept mapping.

Neutral Aspects of Experience

Some students portrayed the use of CMs as having no significant impact on their mathematics learning experience. They saw it as neither aid nor a disadvantage to their process of learning. Students accustomed to a traditional teaching or learning method may not be comfortable with new methods or may not benefit from the extra time and effort needed to introduce the new approach. Some other students regarded the definition maps as evaluations. As a product for outside review instead of a method for significant learning or metacognition, they approached concept mapping.

Concept Mapping and Relating Mathematical Concepts

Connecting mathematical concepts were seen as a key advantage and a key obstacle to the usage of CM in mathematics learning. Integrating thoughts and linking ideas are daunting aspects of mathematical reasoning and data analysis. Some students have encountered the opportunity to relate new concepts through concept mapping to their current knowledge. They considered this incorporation of concepts and contexts as the start of mathematical literacy.

Some other students who said they were struggling to learn mathematics concepts viewed the connections needed in concept mapping as helping them understand the concepts better. Some students perceived that their use of concept mapping impaired their ability to relate the research ideas holistically. Progressive mapping helped them to deepen understandings and incorporate their knowledge more meaningfully.

Numerous students' demonstrated difficulty linking concepts in their maps, and some suggested that because of this problem, they felt that their comprehension of the mathematical concepts was not correctly reflected in their CMs. In design mapping, constructing proposals is a demanding ability that is strengthened with practice.

Concept Mapping and Applying Mathematical Concepts

Students who considered concept mapping useful in applying mathematical principles demonstrated that concept mapping's organisational advantages provided them with a guide or a set of instructions on how to apply relevant concepts to problem-solving. The fact that these maps are student-generated can influence the participant's problem-solving abilities since the learners have actively integrated their individual information systems.

Implications for Practice

The outcomes of this investigation show the ability of concept mapping to enhance studying the concepts of introductory mathematics. Concept mapping can help some learners connect and link mathematical concepts, which can assist in mathematical reasoning development. Although the study findings indicate that students did not see the ability of concept mapping to help them incorporate the concepts, they were studying, more integrated use of concept mapping and problem-solving could

ultimately have the effect of helping students solve problems by visualising the information structures required to solve problems.

In individual and group environments, this integration of concept mapping and problem-solving could be applied. In combination with a group problem-solving exercise, idea maps could be created collaboratively. The node for that concept can be generated on the map when a new concept or idea is used in the problem-solving phase. The next step or idea will then be connected to the CM in the problem-solving process, and a plan would be created. The CM will be structured in this way related to the iterations of the method of problem-solving.

More possibilities and support for the revision of design maps will also increase their efficacy and utility. Participants noted that to reflect their interpretation of how the concepts were related accurately, they needed to make any changes to their charts. They also noticed that links were updated over time as they sought to assimilate new ideas into their current maps. Providing students with several possibilities for revising their topic maps will help students separate concepts, recognise and resolve knowledge gaps and misconceptions, and incorporate knowledge.

The study's results also suggest encouraging the use of various mathematics learning methods. The participants' mixed perceptions and feelings about the usage of CM for mathematics learning may be because people are learning mathematics in various ways. Some participants stressed their individual learning styles as either consistent with or inconsistent with concept mapping.

The following table illustrates students' capacity to understand mathematics, both in an experimental and controlled group

Statistics	Group	
	Control	Experiment
The number of students (n)	100	100
Average	44,85	56,51
Standard Deviation (S)	15.69	14,18

Normality test of the learners' capability to transmit mathematical understanding data determined by the Chi-Square test. In the table below, you can see the full test outcome.

Table 3.: Normality Test Calculation Outcome

Groups	N	x^2_{obs}	x^2_{table}	Conclusion
Experimental	100	4,78	9,47	Normal distribution
Control	100	1,76	9,47	Normal distribution

It could be inferred based on Table 3 that the distributions data of the mathematical understanding skill of students in the control group and experimental class are normal distribution. The homogeneity test was conducted using the Fisher test, and the outcomes of the measurement are in Table 4 (below).

Table 4.: Homogeneity Test

Groups	n	F_{obs}	F_{table}	Conclusion
Control	100	1.58	1.73	Variance homogenous
Experimental	100			

H_0 is accepted because of $F_{obs} < F_{table}$ (1.58<1.73), which implies that all sample groups have the identical or homogeneous variance.

Built on the hypothesis testing conducted, it indicates that the capability of learners to understand mathematics with the definition mapping learning approach is greater than the average capability to understand mathematics by using traditional learning approaches. As follows, to test the hypothesis: H_0: $\mu 1 \leq \mu 2$ and H_1: $\mu 1 > \mu 2$.

The outcome of the measurements, meanwhile, indicates that $t_{obs} > t_{table}$(3,300 > 1,669). Thus, H0 rejected, i.e. the average capability to understand mathematics in CG is lower than experimental group. To sum up, the effects of the t-test is in the table 5(below).

Table 5.: Hypothesis Test Outcomes with t-Test

Groups	n	$\bar{x}$	S.D.	t_{obse}	t_{table}	Conclusion
Control	100	44,85	15.69	3300	1669	Reject
Experimental	100	56,51	14,18			H_0

The study results indicated that the average post-test score in the experimental class was 56.51. The student's post-test score is equivalent to 36.11 per cent at intervals of 52-60. However, the number of students with a score above the average is around 38.89%. In the CG, they obtained an average post-test score of 44,85. The student's post-test score is equivalent to 30,56 per cent in the 43-53 intervals. However, the number of students scoring above the average is around 27.78%.

While the % of students who scored higher than the average score in the second grade show a lower rate, it is obvious that there are substantial variations that the average post-test score in the experimental group is 11.64 per cent greater than in the CG. This suggests that the learning approach utilizing a map definition affects the mathematical comprehension capability of the students. Scholars have studied that there are a variety of things that distinguish among the average control class score and the experimental class:

1. The learning process in the classroom;
2. Concept mapping generated by students; and
3. The mathematical understanding ability of students.

At the initial meeting, in the experimental class, a private meeting was held. The learning process went very well when the instructor explained the beginning of the material using the definition map form. However, the students in this class are hesitant to ask queries when there are not recognized items, but the learners also appear less courageous to convey an idea. This may be because it is yet in the course of adapting to the new learning atmosphere.

This makes learners further involved and tough to increase their learning outcomes, particularly in the mathematical relation ability aspect. At the beginning of the CG meeting, the similar circumstances existed in the CG as in the experimental class. The learners were not much involved throughout the learning phase. Several variables triggered this situation; that could also be

because of the transformation phase. The students began learning process in the next meeting through a conversation with the instructor as a reference for the facilitator. The group discussions are generally done in learning mathematics in the control classes and the experimental one to display their excitement throughout the debate.

This is possible because the students assume that there is a fresh revolution in the learning events. Therefore, they stayed not much satisfied with the debate, impacting the presentations of the present community. Just a few students attempted to present to the class the consequences of their debate. Creating a CM would allow learners to revisit the concepts taught at the time and then try to link the CM with the other CMs generated in the earlier meeting. The learners attempted to categorize the concepts. It turns out to be part of a more comprehensive concept. This makes it simpler for learners to store and process data.

Conclusion

The work's key objective is to show the usage of CMs to upgrade the meaningful teaching of mathematics. The concept was to find the path in which concept mapping may be utilized as a tool that gives students a chance to build combined paths of experiencing conceptual mathematics that they should learn. The research revealed that students taught using concept mapping recorded improved and considerable post achievement and retention scores than those taught using the conventional method. The research also explored the impact of concept mapping strategy on learners' accomplishment in all levels of cognitive abilities. This was found to be significant at all cognitive level. The result of the research showed that concept mapping is an effective approach to learning and teaching Mathematics.

To successfully manage information using the tools for knowledge visualization, teachers must involve themselves in professional training. If they have a positive attitude, teachers can achieve this independently. For more noticeable results, it is essential to organize the forms of acquiring professional knowledge and skills needed for working with students. Finally, it may be recommended that teachers must be well-skilled in implementing the concept mapping learning strategy, teachers must double-check the CMs created by the learners are right or wrong, and teachers must be alert to the learners while performing the assignment offered.

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