ADVANCE SOCIAL SCIENCE ARCHIVE JOURNAL
Available Online: https://assajournal.com
Vol. 04 No. 02. October-December 2025.Page# 4103-4116
Print ISSN: 3006-2497 Online ISSN: 3006-2500
Platform & Workflow by: Open Journal Systems
https://doi.org/10.5281/zenodo.19054214

Effect of Digital Concept Mapping Teaching on Students' Learning Performance at Secondary School Level

Muhammad Rukhsar
Ph.D. Scholar, (Institute of Education & Research), University of Science and Technology, Bannu, KP, Pakistan.
Email: townrose158@gmail.com
Dr. Gulap Shahzada
Associate Professor in IER, University of Science and Technology, Bannu, KP, Pakistan.
Email: gulap-786@yahoo.com
Dr. Uzma Syeda Gilani
Lecturer in IER, University of Science and Technology, Bannu, KP, Pakistan.
Email: uzmasyedagilani@yahoo.com

ABSTRACT
The application of new and modern techniques has determined the international agenda at all levels, especially at the secondary level because it prepares learners to accomplish future tasks and enables them to compete with learners internationally. The research study in hand has investigated how the teaching of the digital concept mapping affects the learning performance of learners at secondary school level. When performing the research study, the following objectives were established: 1. To establish how teaching Digital Concept Mapping would affect the learning performance of learners in the subject of physics at secondary school level. 2. To investigate and compare the effect of digital concept mapping and traditional instructional approaches on the learning performance of learners in the subject of physics at secondary school level. Null hypotheses were developed in line with the objectives of the research. Ho1: The means of the pre-test scores of physics' students taught with DCMT (Digital concept mapping teaching) and Traditional Teaching Method are not different significantly. Ho2: There is no significant difference between the means of pre- and post-test scores of the students of physics who received instruction by using DCMT and the mean score of the students who received instruction by making use of the traditional instruction method. Ho3: The mean score of pre-traditional teaching and post-traditional teaching is not significantly different between the learners in the subject of physics at secondary school level. The population of the study included all the students who study in 10th Grade (270 students) in Bannu Model School and College. This study has randomly sampled 80 learners. The selected students were divided randomly into two equal groups, one of which was called the experimental group and the other the control group on the basis of scoring of the pre-test. The research tools that were used to gather data about the learners were pre and post-tests. This was a tool that comprised of MCQs of the Grade 10th physics, Digital concept mapping teaching was applied to the students of the experimental group whereas the researcher applied the traditional approach used in teaching students of the control group. The post-test is the period that follows the treatment and is used to determine the impact of

treatment. Data analysis further was performed with respect to the objectives, and hypotheses, on the basis of paired sample t-test and independent sample t-test to obtain concrete results. These findings revealed that there was a big difference in the mean score of the students who were taught by the two methods giving out the conclusion that students scored better in terms of learning performance compared to that of the students in the control group. The researcher suggested that Digital Concept mapping teaching be implemented in all other institutions to enhance the learning performance of the students and meet the challenges of 21st-century learners.

Keywords: *Digital, Concept mapping, Effect, Learning performanc, Secondary School*

INTRODUCTION

Quality education is what we usually talk about. To achieve the quality of education, the curriculum must be taught effectively to attain the desired goals. The quality of secondary education is highly valued by researchers as it gives a strong foundation for higher education. Presently, there is a lot of stress on personalized learning and learner independence. Most of the time, learners are expected to know their strengths and weaknesses and to be accountable for learning. However, due to the lack of alignment between objectives, activities, and assessments in traditional teaching (where chalk and talk have been commonplace in learners), it does not suite well with 21st-century practice. Instead, students of today require a revolutionized and contemporary teaching mode in school. There is also the educational system to be better later on, and it will not be administered in the same manner as it was administered in the past. To this end, researchers have come up with numerous useful new ways of teaching including visual learning, project and experimentation approaches. Among them, the largest emphasis is on visual type of learning. Visual aids are used by the Gradees to support this (Shabiralyanni et al., 2015) because they facilitate thought processes and better the learning environment within a Graderoom. The process of knowledge construction defines the meaningful learning process and depends on the thinking structure that is based on the relation between learners (Ghorai and Guha, 2018).

Concept mapping, according to the pre-service teachers, makes it easier to design instructional activities and has a higher quality impact on carrying out duties. Mahasneh (2017) conducted a quasi-experimental study on students' performance levels using idea mapping and conventional classroom counseling techniques. The findings showed that the researchers who employed the idea-mapping technique performed better than the students who depended on traditional classroom preparation. This supports the findings of Dhindsa (2011), who indicated that students who get instruction using a traditional method perform better as they progress through the cognitive stage, structural knowledge, and Grade training. Schaal (2010) claims that the process of idea mapping extends the knowledge of the three primary academic taxonomies, i.e., the cognitive, emotional, and psychomotor domains. Concept mapping helps students acquire critical thinking skills, which form the foundation of the cognitive domain. The fundamental subject of the emotional domain, however, is the notion that researchers can put into practice; similarly, the psychomotor field's core is the motivating stage that students go through with their teachers. Consequently, concept mapping's user-friendliness promotes the addition of instructional taxonomy, which in turn improves student education. College students' unclear and perplexing educational standards are clarified by concept mapping, which also enables them to relate those terms to a variety of scholarly concepts (Moreira et al., 2013).

Concept mapping, according to the pre-service teachers, makes it easier to design instructional activities and has a higher quality impact on carrying out duties. Mahasneh (2017) conducted a quasi-experimental study on students' performance levels using idea mapping and conventional classroom counseling techniques. The findings showed that the researchers who employed the idea-mapping technique performed better than the students who depended on traditional classroom preparation. This supports the findings of Dhindsa (2011), who indicated that students who get instruction using a traditional method perform better as they progress through the cognitive stage, structural knowledge, and Grade training. Schaal (2010) claims that the process of idea mapping extends the knowledge of the three primary academic taxonomies, i.e., the cognitive, emotional, and psychomotor domains. Concept mapping helps students acquire critical thinking skills, which form the foundation of the cognitive domain. The fundamental subject of the emotional domain, however, is the notion that researchers can put into practice; similarly, the psychomotor field's core is the motivating stage that students go through with their teachers. Consequently, concept mapping's user-friendliness promotes the addition of instructional taxonomy, which in turn improves student education. College students' unclear and perplexing educational standards are clarified by concept mapping, which also enables them to relate those terms to a variety of scholarly concepts (Moreira et al., 2013).

Problem statement

Learning is a lifelong process. Teachers train young learners about the existing things around them so that they can learn about the world. The learning process should be such that it stuffs information in the minds of students, but should also inculcate meaningful knowledge in the minds of students. In Pakistan, most teachers use traditional methods of teaching in Grade rooms, and they are not fully aware about the new methods of teaching used in advanced countries of the world as it is generally observed; resultantly the students' performance is not up to the mark. The researcher is interested in applying the new method of teaching, known as Digital Concept Mapping teaching. It enables learners to connect new information with prior knowledge and enhances their comprehension and retention of complex scientific concepts (Lotfi, et al. 2025). Moreover, research in Pakistan has also reported that students taught through concept mapping strategies demonstrate better learning outcomes than those taught through conventional methods (Ajmal, et al., 2022).). Owing to the above advantages there have been conducted limited researches in this specific area and still exist a gap in schools regarding digital concept making. Keeping in view all these, there is a dire need to conduct a study to examine the digital in concept mapping teaching on students' performance in the subject of physics at secondary level.

Objectives

The key objectives were as under:

1. To find out the effect of digital concept mapping teaching on the learning performance of the students in the subject of physics at secondary school level.
2. To analyze the effect of traditional method of teaching on the learning performance of students in the subject of physics at secondary school level.
3. Comparing the effect of digital concept mapping's teaching and traditional teaching methods on learners' learning performance in the subject of physics at secondary school level.

Research Hypotheses

The research study was guided by the following research hypotheses.

$H_0$1: There is no significant difference between the mean pre-test score and post test scores of the students taught through Digital Concept Mapping in the subject of Physics at secondary school level.

$H_0$2: There exists no significant difference between the mean pre-test scores and post-test scores of the students taught through Traditional Teaching in the subject of Physics at secondary school level.

$H_0$3: There is no significant difference between the mean post-test scores of the students taught through Digital Concept Mapping Teaching and Traditional Teaching in the subject of Physics at secondary school level.

Significance of the Study

The study was significant on the following grounds;

1. The study would enable the students to improve their learning performance in physics through digital concept making at secondary school level, because the subject of physics is too ambiguous to understand.
2. The present study would create awareness in teachers about DCM teaching.
3. The study would offer valuable perceptions for instructors by establishing efficiency in digital concept mapping in classrooms by developing such techniques which leads to achieve learning objectives.
4. It would also help and support curriculum developers to prepare a curriculum according to the DCM teaching.

Delimitation of the Study

As it is an experimental study, therefore, keeping all the factors and resources in mind, the desired data was gathered from the 10th grade science students at Bannu Model School and College. Hence the present research was delimited to:

1. 10th grade science students (Male) at Bannu Model School and College, Bannu.
2. The subject of physics (1-S.H.M. and waves, 2-Sound).

REVIEW OF THE RELATED LITERATURE

This portion “The overview of literature” is the maximum comprehensive analysis of the already published work of different authors. It supports brand-new researchers to find gaps within the works already executed in the field. The researcher attempted to study all the work performed on the effect of the concept mapping approach on improving students’ mastery. An analysis of the literature was conducted for the previously documented idea of frame working teaching and its uses.

Yıldırım and Şahin, (2020) argues that the goal of schooling is to raise citizens ' knowledge and capacity to use statistics to solve their problems. All these techniques must be carried out in an organized way with the concept of teaching technology, which is a crucial area in growing those traits and characteristics in people. Instructors must establish interactive and green learning surroundings

Awudi and Danso, (2023) state that DCM has assisted the learners by providing a system to consolidate and demonstrate knowledge in a planned way. This method helps the students to connect ideas that support and fill in science subjects. The research studies have confirmed that DCM can bring betterment and assist the learners to remember complicated scientific details by encouraging them with the contents rather than making rote memorization (Bizimana 2025).

Reshma, (2025) argues that concept mapping pushes the learners to examine their knowledge critically, which is beyond surface learning to gain in-depth knowledge. The learners are encouraged to get

to know how scientific ideas are connected, which is considered the basic requirement of the connection between complicated ideas (Akintola and Odewumi, 2023). The visual setup helps the learners in dealing with large ideas and vast information, making the process easier to comprehend rather than being overwhelmed by vast data (Chang et al., 2023).

Concept mapping enhances the active role of the learners to build their own understanding. This idea fits with the ideas of constructivists as it plunges the learners into the content themselves and organizes and links the various ideas (Bizimana, 2025). As endorsed by theories of learning, change in the behaviour or the learning process occurs best when the learners learn the content or materials where they feel themselves personally relevant and interlink their previous knowledge with their old ones (Lin et al, 2025). Concept mapping tactic is totally changed from outdated rote learning, where it becomes very difficult to connect one idea with another (Chen et al., 2024). MacLeod, (2023) states that relying only on students' responses and staff members, it would have been concluded that the implementation of this new tool was more authentic and positive than the analysis of the quantitative data. However, it is pertinent to believe that both opinions are correct as the concept maps assisted in filling the gap in the postgraduate study in the UK, while on the other hand, the same failed to discriminate between the various levels of achievement.

Sang, 2025) opined that markers were allowed to use the whole of the marking range. This decision was taken to award marks for the submission of the work, irrespective of the quality. However, it was concluded that concept maps as an assessment tool had been partially successful in achieving the said aims. DCM brings more fruits and benefits, higher output, extensive work, and the integration of multimedia.

Khazen, (2024) conducted another research, it was explored how the DCM affected the learners of the 6th Grade in an Arab Primary school. In the research, a quasi-experimental approach was adopted. To analyze the results, numbers and personal experiences with the tests before and after were conducted, along with discussions, instructor transcripts, and learners' feedback

Application of DCM in Science Grades

The application of DCM in science Grades is necessary because it makes the science subjects more understandable and accessible for the learners. The logic behind this is that abstract things are considered more difficult for the learners (Bizimana et al., 2025). The educational institutions where the old methods of teaching are used cannot overcome these challenges, leaving some educational gaps in students (Kpiranyam et al., 2024). DCM makes the learners capable of setting up ideas in a way that lets them see how those ideas are interconnected. And thus assists the learners to understand things in a better way (Chen et al., 2024). It is very appropriate and fit for the mental growth of the learners of 6th grade, who are the beginners to think about more complicated ideas and build a grand building of their career on the developing skills.

Impacts of DCM on Science Learning

Constructivists' approaches confirm the notion that students build ideas themselves rather than absorb the knowledge and information. New ideas are to be combined with the old and previous knowledge (Anastasiou et al., 2024). DCM motivates the learners to ask questions, explore, and solve their problems to understand in a better way (Chang et al., 2023; Chen et al., 2024). The exponents of constructivism encourage learners to develop critical thinking and to connect various things, which is very helpful to get hold of various scientific problems (Anastasiou et al., 2024). In the Graderoom of constructivism, the role of a teacher is that of a guide and not a source of answers. It creates a sense of responsibility in learners as they themselves feel free to learn, and if they find any difficulty in the learning process, the guide guides them in a friendly way (Jack et al., 2023).

RESEARCH METHODOLOGY

This part is consisted of research design, population, sample, variables and procedure of the study.

Research Design

In the present research study, two groups were made: an experimental group (EG) and a control group (CG), in which the students were selected randomly, and the students went through a pre-test and a post-test. Hence this was a true experimental study, pre and posttest controlled group design was used. This design has been illustrated by the diagram given below.

(Experimental Group) RE O1 T O2
(Control Group) RC O3 O4
R= Randomly Selected groups E= Experimental Group
C= Control Group O= Observation
T= Treatment

The two teaching approaches i.e. the digital concept mapping teaching, and the traditional one are the independent variables in this research study as the dependent variable is the learning performance of the learners.

Population

The population of the study was all the tenth-grade science students of Bannu Model School and College, Bannu, during the academic year 2022-2023. In this way, the number of the studied population was 270.

Participants in the Study

Eighty (80) students who were selected randomly from 270 students of 10th grade studying in Bannu Model School and College, Bannu. Two groups, i.e., an experimental group and a control group were made, and each group consisted of 40 students from the 10th Grade who were selected. Students of the experimental group were taught through Concept mapping teaching while students of the control group were taught through the traditional method.

Equalization of Groups

The required data has been collected by using a random sampling technique. First, the researcher collected data about the students' age, the education of their parents, the number of siblings, locality (rural/urban), and the score they got in the 9th Grade examination (A) 2019 from BISE Bannu. The learners were selected between the ages of 15–17 years. Variable regarding the parents' education was controlled in selecting learners for the experimental group and control group. Eighty (80) learners were randomly selected for both groups, where each group consisted of 40 learners.

Study Variables

In the present research study, the dependent variable was the educational achievement or learning attainment of the learners because of the treatment given during the experimental process. Similarly the teaching method (DCM Teaching to the experimental group and conventional method of teaching for the control group) is an independent variable. Additionally, the extraneous variables were the demographic variables that include location, parents' education, number of siblings, family income; students' age, gender, and time which are beyond control.

Experimental Procedure

The researcher selected randomly 80 students of the 10th Grade of Bannu Model School and College, Bannu, an Experimental group and a control group. The students for each group were selected randomly. Both groups were given a test in such a way that after marking the test, both groups had equivalent marks and equal strength of 40 students. The researcher himself taught the experimental group through the concept mapping teaching method and the control group through the traditional method of teaching for 8 weeks. The syllabus consists of the units of Physics (1-S.H.M. and waves, 2-Sound).

A post-test is administered at the end. For example, simple harmonic motion is taught by digital concept mapping teaching as such.

Groundwork for the Experiment

Learners of the control group were taught through the traditional method of teaching. The question and answer sessions, the rote learning of dialogues, replacement drills, and practices of speaking, reading, and writing practices techniques were applied as well as the teaching method that was based on concept mapping for the experimental group was used. Various activities such as games of words' formation, puzzles for searching words, activities of reading and writing, games, matching exercises, Grade identification and categorization, PowerPoint presentations, flashcards, miming games and hands-on activities, peer work, group work were applied.

Lessons' Presentation

A lesson plan consisting of a seven-step procedure of lesson plan procedure was applied, as approved by two more elements that were added to these seven steps, as the researcher thought these were best suited. These steps were:

1. Specification of aims,: A program was made for attaining precise instructional objectives according to the concept mapping teaching method. While selecting a specific topic, the focus of the research was the topic "Sound" in Physics or the topic of "The teaching of physical activities.

2. Asking basic questions,: The students were involved themselves in physical activity at the production of sounds of different intensities, that is, shrill and grave sounds in physics.

3. Brainstorming: A concept map Planning Sheet, was used. Besides this, he may also use some other techniques to stimulate the learners, like displaying and showing the charts about some topics. Brainstorming was proven to be very supportive in stimulating the learners.

4. Selecting activities according to the needs of the learners,: The researcher made charts to make a concept clear and understandable to the students by using various techniques to warm up the students.. Likewise, group activity was utilized to discuss which leads to the generation of new ideas, i.e., examples of physical change. To understand the concept of "gravitational force" in physics, a ladder activity was used

5. Establishing a plan with having sequence: A sequential plan was followed to achieve the objectives. So, all the tasks and activities were carried out in a systematic and planned manner, so that each activity or task might provide a base for the next one.

6. Executing the strategy and plan: The required funds and resources were gathered, and an appropriate time slot was selected for the operationalization of the lesson plan.

7 Reflection,: The researcher reflected upon the activities through various types. Sometimes, the researcher asked CCQs, for instance: after having taught "physical change", the researcher asked the students about what they thought about physics.

8. Feedback: Feedback was given by the researcher at the end of each activity, which was based on the progress of the learners. This task was performed in the form of peer feedback, i.e., nominative feedback, where the learners were supposed to give feedback about the activity. This feedback was constructed by the learners in the form of positive areas of improvement, and again, positive, depending on their performance.

Test Item Analysis

For the tests' validation, the researcher contacted research experts, the University of Science and Technology Bannu, and subject experts in Chemistry. It was tested by professors, assistant professors, and subject specialists. The original 37 test items were prepared by the researcher. The content validity of the test was judged and 4 questions were rejected, 5 questions were refined and after the whole process 33 questions were finalized to test.

Data Analysis

The researcher analyzed the gathered information using descriptive statistics as well as inferential statistics. To this effect, both, pre-tests and post-tests of both the experimental and control group were done using Mean and SD, paired sample t test and independent sample t test.

Paired sample t-test was to determine the effect of the treatment or concept mapping teaching on the learning attainment of learners.

The use of independent sample t-test was used to compare the pre and post test scores of the different group.

Ethical Considerations

During the study, all the ethical principles were followed by the researcher. Special permission was received from the parents of the students. All the participants of the control group were also re-teaching the same chapter by the digital concept mapping teaching method by the researcher.

ANALYSIS AND INTERPRETATION OF DATA

The presentation and data analysis have been carried out in this part. The collected data was analyzed through SPSS-23, applying descriptive statistics and inferential statistics. For this, SD, paired sample tests, and an independent sample t-test were applied to find out the concrete results. Through this analysis, a comparison between the traditional method of teaching and digital concept mapping was made. Moreover, the impact of teaching digital concept mapping on the students' learning performances was found.

Table 1: **Results of the independent sample t-test for pre-test scores of EG and CG**

Group	No	Mean	SD	t-value	df	p-value
EG	40	18.48	5.63	0.12	78	0.74
CG	40	18.32	5.68			

Table 1 illustrates results of independent sample t-test where the mean scores of the EG are 18.48 CG is 18.32 and the standard deviation of the experimental group is 5.63 and the control group is 5.68. Moreover p-value is 0.74 that is greater than .05. It means that in the beginning of the research study both the groups were similar.

Graphical presentation of pre-test scores of EG and CG.

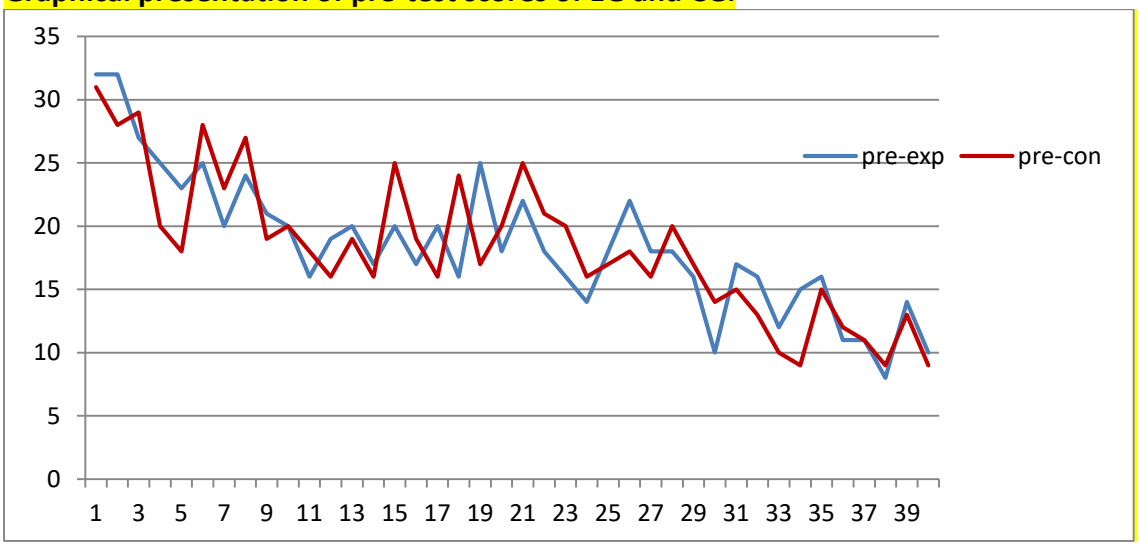

Figure 1

Table 2 Results of paired sample t-test for pre-test and post-test scores of CG

Group	No	Mean	SD	t-value	df	P-value
Pre-test	40	18.32	5.67	10.03	39	.00
Post-test	40	20.32	5.37			

Table 2: indicates the results of the paired sample t-test of CG, where the mean scores of the pre-test and post-test of CG were found as 18.32 and 20.32, with SDs of 5.67, 5.37, respectively. The value of p is less than .05, which indicates the difference between the pre-test score and post-test score of CG, but this difference is so small that it can be negligible.

Graphical demonstration of pre-test and post-test scores of CG.

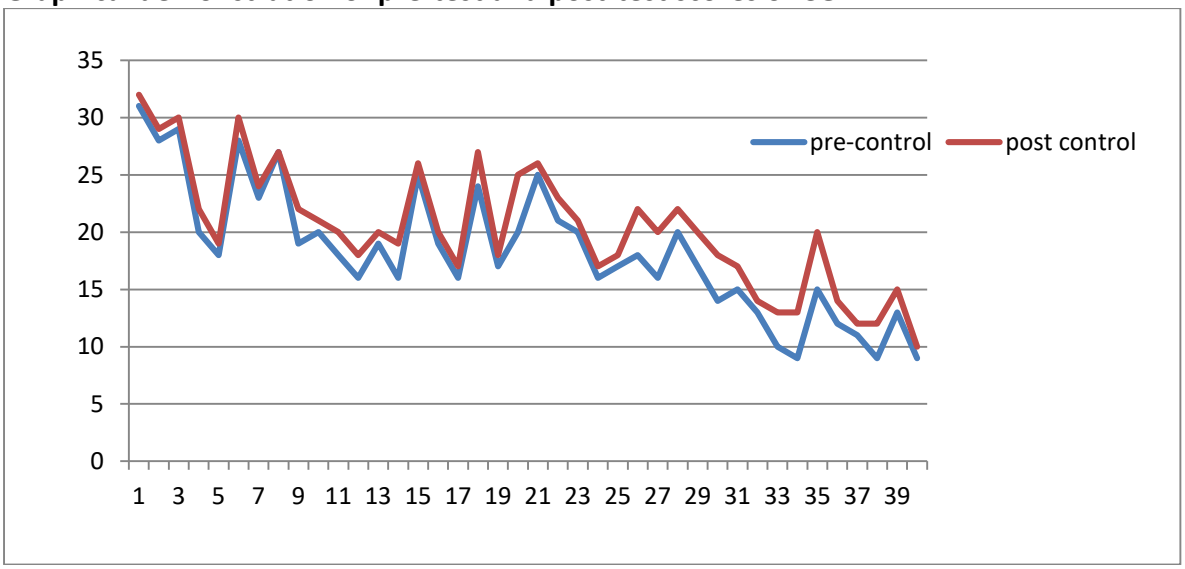

Figure 2

Table 3 Paired sample t-test for pre-test score and post-test score of EG.

Group	No	Mean	SD	t-value	df	P-value
Pre-test	40	18.47	5.46	15.09	39	.00
Post-test	40	24.55	4.34			

Table 3: illustrates the results of the paired sample test for pre-test and post-test of EG, where the mean scores for pre-test and post-test of EG are 18.47 and 24.55, with SD of 5.46 and 4.34, respectively. The p-value is .000, which is less than the .05 that indicates that there exists a significant difference between the pre-test and post-test scores of EG. It indicates that the treatment (concept mapping teaching method) affected the EG positively, as the learning outcomes of the EG were better.

Graphical presentation of pre-test and post-test scores of the EG.

Figure 3

Table 4: Independent sample t-test score and post-test scores of EG and CG.

Group	No	Mean	SD	t-value	df	p-value
EG	40	24.55	4.34	3.86	78	.00
CG	40	20.32	5.37			

Table 4 displays the results of an independent sample t-test where the mean scores of EG and CG are 24.55 and 20.32, respectively. The SD value for the experimental group is 4.34, while for the control group it is 5.37, respectively. There exists a significant difference between the two groups as the p-value is less than .05.

Graphical demonstration of post-test scores of EG and CG

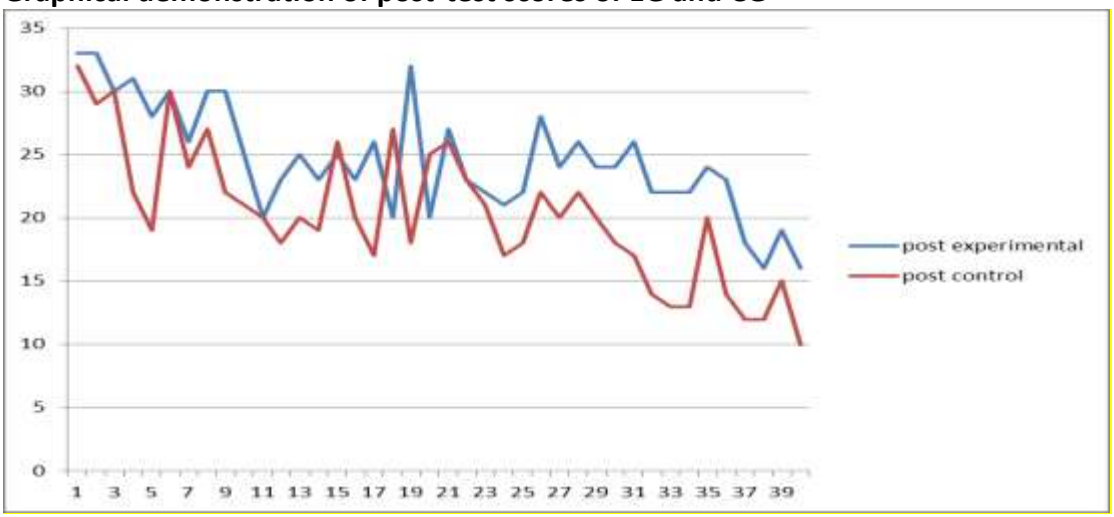

Figure 4.

Table 5 Effect size of treatment

Group	Mean	SD	t	p	Cohen's D	Effect-size r
Post-experimental	24.55	4.34	3.86	.00	0.87	0.40
Post-Control	20.32	5.37				

Table 5 illustrates the effect size of the treatment, which has an average value of 0.40, showing that the treatment has shown a positive impact on learners' learning attainment.

RESULTS

1. The mean scores of the EG and CG in the physics course were found as 18.48 and 18.32, respectively, while the SD of EG and CG were recorded as were 5.63 and 5.68, respectively. With a p-value of 0.74 as it was higher than the significance level of.05. Since there is no significant difference between the pre-test scores of both the groups, hence the first sub-hypothesis was accepted.
2. Pre-test and post-test mean scores of the CG in physics were recorded as 18.32 and 20.32, respectively, with SD of 5.67 and 5.37. There exists no significant difference between the mean pretest score and post-test score of the CG in physics because the p-value is less than .05, indicating that there is a difference between the pre-test score and post-test score of the CG are However, this mean score difference is extremely small.
3. The pre-test and post-test mean scores for the experimental group in the physics course were 18.47 and 24.55, respectively, with standard deviations of 5.46 and 4.34. The significance level of.05 is exceeded by the p-value of.000. The experimental group's pre-test and post-test scores have a significant difference, which suggests that the treatment (concept mapping teaching technique) had a favorable impact on the group since their learning outcomes have improved.
4. In physics, the mean scores of EG and CG mean scores were found as 24.55 and 20.32, respectively, with standard deviations of 4.34 and 5.37. At .00, the p-value is below the significance level of .05. The effect size

has an average value of 0.40, indicating that there is a substantial difference between the two groups and that the treatment has a good and favorable impact on students' academic success.

Discussion

This experimental research has tried to implement Digital concept mapping teaching activities to establish the effect of this teaching on the performance of the students in physics subject in secondary school level.

It is clear in the tables of analysis that initially, the two groups were equal and that the difference between the two groups was not significant (P.005). However, the post-test carried out after treatment showed that the p-value (.00) indicated a significant improvement in the academic achievement of students through the teachings given using the Digital concept mapping method. Therefore, the study null hypothesis has been rejected.

Findings indicated that there was no significant difference between the pre-test scores of the experimental and control groups before the treatment, showing that both groups had a similar level of prior knowledge in Physics. Establishing such equivalence is important in experimental research because it ensures that any improvement in students' learning performance can be attributed to the instructional treatment rather than to initial differences among learners.

The results also revealed that the control group showed only a slight improvement in learning performance after being taught through the traditional teaching method. This limited progress may be due to the continued use of lecture-based approaches in many Pakistani secondary schools, where teaching often emphasizes rote memorization rather than conceptual understanding. Previous studies in Pakistan have similarly reported that traditional teaching methods restrict students' active participation and reduce their ability to understand complex Physics concepts effectively (Malik et al., 2023).

In contrast, the experimental group showed a significant improvement in learning performance after being taught through Digital Concept Mapping teaching. This indicates that concept mapping helped students organize knowledge, understand relationships among concepts, and develop deeper conceptual understanding of Physics topics. Digital concept mapping also promotes interactive learning and visual representation of ideas, which enhances students' engagement and meaningful learning. These findings are consistent with recent research in Pakistan which suggests that technology-supported instructional strategies, including concept mapping and digital learning tools, improve students' conceptual understanding, critical thinking, and academic achievement in science education (Chang et al.2022; Chang, & Yang(2023)

Conclusions

In this experimental study, an effort has been made to use the digital idea mapping teaching approach, considering the resources accessible in our Graderooms. The study's dependent variables were the academic performance of the students, whereas the independent factors were digital concept mapping instruction and conventional teaching techniques.

This study has attempted to account for the following risks to internal and external validity based on characteristics including age, parent education, number of siblings, and location using the random sampling approach for sample selection. The experiment lasted for eight weeks. The control group was taught using a conventional approach, whereas the experimental group was taught through digital concept mapping. There were no discernible differences between these two groups, according to the pre-test results from the study's initial phase. Post-test results, however, showed that digital concept mapping improved students'

learning performance. Even if the control group's students' test scores have increased, they still fall short of the experimental groups. Compared to the control group, the experimental group has significantly improved. Furthermore, digital concept mapping instruction has impacted students' academic performance in comparison to the conventional teaching approach, as evidenced by the effect size of 0.44 and a value of 0.97 when computed using Cohen's "d."

Recommendations

1. It is advised that teachers should use DCM Teaching in their courses to guarantee that students' learning performance improves, since the results showed that the experimental group outperformed the control group in terms of academic achievement.
2. Training of teachers in pedagogy to be given according to DCM, so that they teach their students according to the principles of digital concept mapping consequently learners performance will improve.
3. Teachers may comprehend DCM before using it, as it requires more work than typical teaching methods.
4. DCM should be implemented in lesson planning and activity design for the students while considering course content objectives.

REFERENCES

Ajmal, F., Shaheen, A., & Hafeez, M. (2022). Concept Maps Learning Strategy In Higher Educational Perspectives Of Pakistan. *Pakistan Journal of Society, Education & Language*, *9*(1).

Akintola, D.A. and Odewumi, M.O., 2023. Effects of concept maps on senior secondary school students' achievement in ecological concepts in Ogbomoso South, Nigeria. *Journal of Education*, *203*(1), pp.3-9.

Anastasio, A.T., Baumann, A.N., Callaghan, M.E., Walley, K.C., Gong, D.C., Talaski, G.M., Conry, K.T., Shafer, C. and Hoffmann, J.C., 2024. The Impact of Surgeon Experience on Surgical Parameters and Complication Rates for the Surgical Management of Adult Spinal Deformities: A Systematic Review and Meta-Analysis. *Prosthesis*, *6*(3), pp.582-595.

Awudi, B. and Danso, S., 2023. Improving students' performance and conceptual understanding of heat transfer using demonstration method. *Journal of Mathematics and Science Teacher*, *3*(2), pp.1-10.

Bizimana, E., 2025. Exploring the Contribution of Perceived Supportive Graderoom Learning Environment to Students' Engagement in Learning. *European Journal of Psychology and Educational Research*, *8*(2), pp.97-112

Chang, C. C., Hwang, G. J., & Tu, Y. F. (2022). Concept mapping in technology-supported K-12 education: A systematic review of selected SSCI publications from 2001 to 2020. *Journal of Educational Computing Research*, *60*(7), 1637-1662.

Chang, C. Y., & Yang, J. C. (2023). Concept mapping in computer-supported learning environments: A bibliometric analysis. *Interactive Learning Environments*, *31*(10), 6678-6695.

Chen, A., Wei, Y., Le, H. and Zhang, Y., 2024. Learning by teaching with: The effect of teachable agent on programming education. *British Journal of Educational Technology*.

Dhindsa, H.S., 2011. Using interactive whiteboard technology-rich constructivist learning environment to minimize gender differences in chemistry achievement. *International Journal of Environmental and Science Education*, *6*(4), pp.393-414.

Ghorai, S. and Guha, A., 2018. Effectiveness of Concept Mapping Strategy on Physical Science Learning. *International Journal of Research and Analytical Reviews*, *5*(3), pp.1014-1020.

Jack, R., Halloran, C., Okun, J. and Oster, E., 2023. Pandemic schooling mode and student test scores: Evidence from US school districts. *American Economic Review: Insights*, *5*(2), pp.173-190.

Kar, B., Kar, S., Rath, N., Das, M. and Kar, N., 2025. The psychological stress of returning to in-person institution-based educational activities by students in college and universities following the COVID-19 pandemic: A cross-sectional survey. *Odisha Journal of Psychiatry*, *21*(1), pp.9-14.

Khazen, M., 2024. Fostering Decision-Making and Ethics: Problem-Based Learning for Female Tertiary Learners in Israel. *European Journal of Educational Research*, *13*(3).

Kpiranyam, F.S., Achor, E.E. and Fakaa, S.G., 2024. Scaling up emotional intelligence and critical thinking of students in biology using two concept mapping strategies. *Faculty of Natural and Applied Sciences Journal of Mathematics, and Science Education*, *5*(4), pp.92-101.

Lee, J.H. and Segev, A., 2012. Knowledge maps for e-learning. *Computers & Education*, *59*(2), pp.353-364.

Lin, Z., Dai, Y. and Ng, O.L., 2025. Constructionism in K-12 AI Literacy Education: A Systematic Review of Pedagogical Designs, Student Outcomes, and Learning Mechanisms. *Journal of Educational Computing Research*, p.07356331251360442.

Lotfi, F. Z., Suwartono, T., Maziane, B., Nurhayati, S., Laajan, Y., & Nachit, B. (2025). Collaborative Concept Maps in Higher Education: Pedagogical Contributions, Cognitive Challenges, and Optimization Strategies for Interactive Visual Learning. *Educational Process: International Journal*, *14*, e2025085.

MacLeod, E., 2023. *The status and safety of teaching: A longitudinal study of why some young people in England become teachers, and why others do not* (Doctoral dissertation, UCL (University College London).

Mahasneh, A.M., 2017. The effect of using electronic mind mapping on achievement and attitudes in an introduction to educational psychology course. *The new educational review*, *47*, pp.295-304.

Mallik, S et al., (2023). Proactive and reactive engagement of artificial intelligence methods for education: A review. International Journal of Educational Technology, 14(1), 1- 15. https://doi.org/10.1007/s41239-023-00456-9.

Moreira, J., Ferreira, A. and Almeida, A., 2013. Comparing communities of inquiry of Portuguese higher education students: One for all or one for each?. *Open Praxis*, *5*(2), pp.165-178.

Reshma, M.Y., 2025. Assessment and Evaluation in NEP 2020: Transforming Learning Outcomes. *From the Editors' Desk*, p.211.

Sang, H.C., 2025. An Analysis of the Challenges Teacher Educators Face when Conducting Teaching Practice in Kenya. *Research Journal of Education, Teaching and Curriculum Studies*, *3*(1), pp.26-33.

Schaal, S., 2010. Enriching traditional biology lectures—Digital concept maps and their influence on achievement and motivation. *World Journal on Educational Technology*.

Shabiralyani, G., Hasan, K.S., Hamad, N. and Iqbal, N., 2015. Impact of visual aids in enhancing the learning process case research: District Dera Ghazi Khan. *Journal of education and practice*, *6*(19), pp.226-233.

Yıldırım, B. and Şahin, F., 2020. Simulation applications: A potential approach for Turkish social work education. *Toplum ve Sosyal Hizmet*, *31*(3), pp.1227-1247.