

# The Impact of Concept Mapping on Students' Self-Directed Learning in Physics at Secondary Level

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## ABSTRACT

The purpose of the research is to determine the impact of Concept Mapping on students' self-directedness in learning physics at secondary level. The study was used pre and post-test control group design with sample of 80 from the students of 9th grade from the Residential Schools of Social Welfare, Telangana. The experimental and control groups consisted 40 each. The students in the experimental group was exposed to Concept Mapping as a learning method for physics and control group was asked to use conventional learning method to learn same topics of physics. Both groups were administered pre-test and post-test using same self-directed learning scale of learning physics before and after intervention. The duration of the study was eight weeks. The researcher developed tools were used for the data collection and these tools were standardized appropriately. The collected data was analysed using descriptive (mean and SD) and inferential statistics such as t-test and ANCOVA. From the results, it is concluded that the students of experimental group have shown higher self-directedness than students of control group. This indicates, there was a significant impact of Concept Mapping on the students' self-directedness in learning physics.

## 1. Introduction

Learning is an important concept which has changed largely with the works of psychologists like Bruner, Ausubel, Piaget and Vygotsky. Changes are observed in the role of learner from passive to active, given importance to learner's experiences and transmission of facts to construction of knowledge by learner. Most of the time activeness is considered as physically active but physical activity alone does not guarantee any mental effort or mental engagement. This indicates that in order to make active minds, learners have to challenge to use their mental abilities or cognitive abilities while learning. But, there are number of barriers to students in learning, they are: physical, cognitive, emotional, psychological, social, and some are motivational barriers to learn on their own. National Curriculum Framework -2005 advocated that to introduce various teaching and learning strategies to become as self-directed learner. Besides, Right to Education Act -2009 also given priority to achieve learning competencies or abilities among school children in order to become as self-directed learners. This can be possible when teacher introduce various teaching and learning strategies in classroom and make them believe in their abilities of learning.

Science encompasses the basic disciplines such as Physics, Chemistry, and Biology. Research shows that the interest levels of secondary level students in science learning is declining and they are not ready to learn on their own. Besides this, Physics is one of the science subjects found as most difficult felt by the students at secondary level curriculum. Physics teachers should aim to eradicate this feeling and develop self-directedness to learn physics by introducing various learning methods to the students.

## 1.1 Concept Mapping

The roots of Concept Mapping lies in science education and it was developed by Joseph D. Novak and his research team at Cornell University in 1970's. In their longitudinal study they focused to understand changes in children's' know ledge of science. The technique of Concept Mapping works based on learning theory of David. Ausubel. According to Novak (2008) "Concept Maps are tools for organizing and representing know ledge. They include concepts, usually enclosed in circles or boxes of some type, and shows relationship between two concepts or propositions indicated by a connected line and a linking word between them. Linking words on the line specify the relationship between the two concepts".

The following figure shows the overview of Concept Maps.

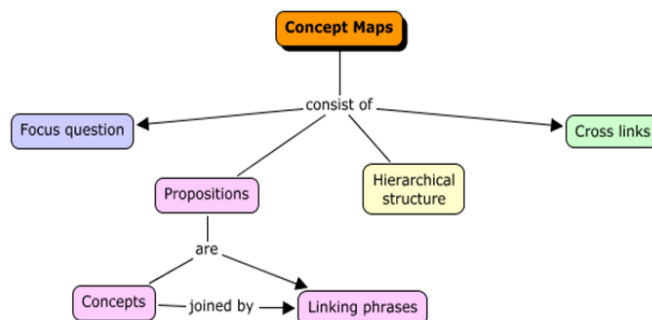


Figure – 1.1: Overview of Concept Maps ("IHMC Public Cmaps (3)," n.d.).

### 1.1.1 Steps to construct a Concept Map:

Different methods can be used to construct Concept Maps. There is no rule to follow particular set of steps in the construction of a Concept Map. Everyone has their own style.

In research field, most of the researcher follow the steps suggested by Novak and Gowin (1984). Concept Maps can be constructed either by hand using paper and pencil or with the help of specific soft wares in computers such as Cmap tool developed by Institute of Human Machine Cognition (IHMC). Further it can be constructed individually or within small groups or whole class with or without scaffolding. The following two theories support the use of Concept Map as learning strategy, they are: Constructivist theory and Ausubel's learning theory.

In this study, researcher used Concept Mapping as an intervention to improve students' self-directedness in learning physics.

### 1.2 Self-Directed Learning

The concept of "self-directed learning" is a key component of adult learning, even though it is very important for the 21<sup>st</sup> century school students where student have a lot of opportunities to learn on their own and plays an active role in the learning process.

There is no commonality in defining the self-directed learning from the research community. The following few definitions were given by the various researchers to understand the nature of self-directed learning.

- Knowles (1975) described broadly Self-Directed Learning (SDL) as "a process in which individuals take the initiative with or without the help of other, to diagnose their learning needs, formulate learning goals, identify resources for learning, select and implement learning strategies, and evaluate learning outcomes" (p. 18).
- As the term suggests, SDL views learners as responsible owners and managers of their own learning process. SDL integrates self-management (management of the context, including the social setting, resources, and actions) with self-monitoring (the process whereby the learners monitor, evaluate and regulate their cognitive learning strategies) (Bolhuis, 1996; Garrison, 1997).

Thornton (2010) stated the following three key stages that help learners succeed in this process, these are:

1. High self-efficacy: capabilities or abilities to undertake any task or activity to succeed (Bandura)
2. Goal-setting: realistic and attainable (Schunk, 1990)
3. Self-monitor and Self-evaluate: self-oriented feedback to evaluate the effectiveness of the process (Zimmerman, 1990)

Some other pointed components that are involved in SDL, they include self-management, self-monitoring, assessing learning needs, collaboration, and self-evaluation. Among these, Knowles (1975) definition widely accepted by research community. In this study, researcher has chosen initiation, self-management, self-monitoring, and self-evaluation as components of self-directed learning.

Various models have been proposed to understand the nature of self-directed learning such as Brockett and Hiemastra's Personal Responsibility Orientation (PRO) Model (1991), Garrison's Self-Directed Learning Model (1997), Candy's Model (1991), Grow's Staged Self-Directed Learning Model (1991).

## 2. Objective of the study

Most of the students show uninterested and afraid to learn physics on their own, in other words, they were not self-directed in learning physics. Hence, the researcher intended to improve the student's self-directedness in learning physics with help of Concept Mapping. Therefore, the objective of this study as follows: "To study the impact of Concept Mapping on Self-Directed Learning of students in learning physics at secondary level".

## 3. Hypothesis of the study

The following hypothesis has been formulated in order to study the above objective.

- The students of Experimental group will have higher self-directed learning towards learning physics when compared to that of the Control group as a result of intervention.

## 4. Materials and method

The purpose of this study is to examine the impact of Concept Mapping on self-directed learning towards learning physics among Secondary School Students. This study used pre-test and post-test control group of true experimental design was used to study the above objective. Researcher has chosen true experimental design because of following advantages, they are:

- Random assignment of subjects,
- Equal treatment of subjects (for the both experimental and control groups), and
- Controlling the extraneous variables.

### 4.1 Sample of the study

The total of eighty (80) subjects were selected and assigned randomly to experimental and control group from the two sections of 9<sup>th</sup> grade students of Social Welfare Residential School of Telangana State during the academic year 2015-16. Each group has been consisted forty (40) students.

### 4.2 Tools of the study

The researcher used following tools to study the impact of Concept Mapping on the dependent variable.

1. Concept Mapping Learning Modules on the unit of SOUND.
2. Self-Directed Learning scale towards learning physics.

### 4.3 Development and validation of tools

#### 4.3.1 Preparation of Concept Map Learning Modules (CMLM)

Researcher developed learning modules of Concept Maps material were used for the selected sub-concepts on the topic of "Sound" by using Institute for Human and Machine Cognition (IHMC) software (Cmap tool). These Concept Maps were used in experimentation to facilitate learning physics for the 9<sup>th</sup> grade students. Learning modules included the following concepts related to Sound.

- Sound is a form of energy, Production of sound, Propagation of sound, Longitudinal waves, Transverse waves (types of waves), Wavelength, Amplitude, Time period and frequency, Speed of sound wave, Pitch, Loudness, Quality, Reflection of sound, Echo, Reverberation, Uses of multiple reflection of sound, Range of hearing, Applications of ultrasound.

#### 4.3.1.1 Pilot Study of the Learning Modules

The pilot study was conducted in schools of TSWREIs after taking the prior permission from the head of the institutions. These schools were selected to serve the purpose of the study, medium of instruction, availability of students and support from the teachers and management. The study was over a period of four weeks during the months of November and December, 2015. During this period researcher asked the students to use Concept Mapping on single group of 47 subjects of IX standard to assess the feasibility of learning material of concept maps on the unit of Sound for the selected sub-topics.

#### 4.3.1.2 Validation of the Learning Modules

The draft was given to three experts (among them, one has knowledge of Concept Maps and two of them were experienced physics teachers teaching in secondary schools) for comments on the validity of the learning module and minor changes were made in the final version of the module based on their feedback.

#### 4.3.2 Construction of Self-Directed Learning Scale of Learning Physics (SDLLP)

The Self-Directed learning scale of learning physics was developed by researcher based on the following questionnaires after reviewing the literature related to self-directed learning scales, these are:

- Learning Experience Scale (PRO-SDLS) developed by Stockdale (2003) based on Personal Responsibility Orientation (PRO) model of Brockett & Hiemstra's (1991) ( $\alpha > .80$ ).
- Self-rating scale of self-directed learning (SRSSDL) developed by Swapna Nasker Williamson et.al. (2007) ( $\alpha = .71$ ).
- Guglielmino's Self-Directed Learning Readiness Scale (SDLRS) ( $\alpha = .94$ ), and
- Garrison's Model of Self-Directed Learning: Preliminary Validation and Relationship to Academic Achievement by Abd-El-Fattah (2010).

#### 4.3.2.1 Reliability and Validation of Self-Directed Learning Scale of Learning Physics (SDLLP)

Based on the above mentioned questionnaires, in the beginning, the researcher produced a draft of twenty seven items. The draft was given to three experts (in that one expert has background of physics as well as psychology) to measure and evaluate to comment on the items in terms of relevance, sentence structure and adequacy of the tool for the students of secondary level. The experts independently assessed each of the item using a 5-point Likert scale ranging from Strongly Agree to Strongly Disagree. A score of 5 denoted Strongly Agree and a score of 1 denoted Strongly Disagree and data were analysed and calculated Cronbach's alpha reliability coefficient is 0.72. Five items were removed and minor changes were made for remaining items accordingly based on their feedback. The 22 items were retained in final version of the tool. This tool contained two distinct parts. The first part seeks to obtain information about student profile (i.e. age, gender, caste, economic status etc.). The second part requested respondents to provide their opinion about items

related to the SDLLP, ranging from strongly agree to strongly disagree. The SDLLP statements were categorized under four sections, namely:

- Initiative (5 items)
- Self-management (5 items)
- Self-monitoring (6 items)
- Self-evaluation (6 items)

The initial try-out of tool was administered with a small group (10-12) and later the final try-out was done with sample of 100 IX standard students as part of pilot study and data were analysed by using the SPSS and calculated reliability coefficient (Cronbach's alpha) for final scale of self-directed learning in physics is 0.77.

#### 4.4 Procedure of the Study

The experiment has been conducted in three stages

- Administration of pre-test
- Implementation of intervention
- Administration of post-test

##### 4.4.1 Administration of Pre-tests

In the beginning of the study, the researcher spent four days to build rapport with students to make them comfort. Later, instructions were given to them regarding the purpose of test. The final form of the test was administered to the both students of experimental and control groups as a pre-test for measuring the level of students' Self-directed learning in physics before intervention. After administering the above tests, the sheets were collected and scored accordingly. These scores served as a pre-test scores for the study.

##### 4.4.2 Implementation of intervention

Following two days, the investigator introduced Concept Maps to the experimental group by presenting examples of showing simple concepts like sun, tree, water, energy, electricity and sound. The Concept Map terminology like node, link, link word or phrase, cross-link were explained and steps in constructing a Concept Map and the scoring procedure were given for self-evaluation. Investigator showed the procedure of constructing a concept map by following steps given in a learning module. Any information was not given to the control group except asking them to learn given concept by conventional learning method.

The classes for both the experimental and control group were taken by the researcher during the morning and evening hours of the school without disturbing the regular periods of school schedule and covered the same topics in the same number of periods for both experimental and control groups. During the intervention period, the classes were altered by the investigator on each day.

Later a learning module was distributed to the subjects of experimental group, and were asked to read the paragraph and construct a Concept Map individually for a given concept by following the steps from the learning module. While construction of map, students were asked to manage, monitor their learning by checking (or evaluating) their own progress individually by using rubrics. Teacher also encouraged them. A copy of same content without steps was distributed to the subjects of control group, and asked them read the paragraph and learn individually by conventional method. The duration of each class was one hour for both experimental and control

groups. During intervention, only one learning module was distributed to the experimental group. The total experimentation phase was eight weeks.

4.4.3 Administration of Post-test

At the end of the intervention, both experimental and control groups were administered again Self-directed learning scale in relation to learning physics as a part of post-test. All the response sheets were collected and scored accordingly. After scoring procedure, the scores of both groups were tabulated and consolidated separately for further analysis of the data.

4.5 Delimitations of the study

The study has the following delimitations.

- This study has restricted to learning physics through use of Concept Mapping.
- This study has restricted to the unit SOUND of 9<sup>th</sup> grade physical science text book of Telangana State.

5. Results and discussion

To analyse the data, Statistical Package for Social Sciences (SPSS) version.22 has been used.

5.1 Analysis of data related to Pre-test Scores of Self-directed learning of students in Learning Physics

Before initiating experiment, in order to find the two groups students have been same (or no differences) level of Self-directed learning in physics learning. To study this the following null hypothesis has been formulated.

- $H_0$ : There is no significant differences between the mean scores of Self-directed learning obtained in the pre-test by experimental and control groups of students.

The above null hypothesis has been tested with independent t-test and the results are furnished in the following table.

Table 1: Showing t-values and p-values on the Pre-test Scores of Self-Directed Learning of Experimental and control Groups.

Dependent Variable	Group	N	Pre-test		t-value (df=78)	Sig. (2-tailed)
			Mean	SD		
Self-Directed Learning	Experimental group	40	79.53	10.231	0.611	.543 <sup>ns</sup>
	Control group	40	78.23	8.725		

Ns-Not significant at 0.05 level

From the table 1, it is observed that the Mean and SD scores of Self-Directed Learning in pre-test 79.53, 78.23; and 10.231, 8.725 for the both experimental and control groups respectively. And also observed  $t(78) = 0.611$ ,  $p = .543 > .05$  when both the groups are compared. So, the obtained "t" value .611 is less than the critical value 1.99 at 78 degrees of freedom and the "p" value .543 is greater than .05 level of significance. Hence, the researcher has evidence not to reject the null hypothesis. This indicates that there is no significant difference has been observed in the mean scores of Self-Directed Learning of experimental and control groups in pre-test. Which means that the level of Self-Directed Learning in physics is same for both experimental and control group of students before intervention.

5.2 Analysis of data related to Post-test Scores of Self-Directed Learning of students in Learning Physics

After the intervention, to determine whether there is a significant difference in the level of Self-directed learning of two groups towards learning physics, the investigator has been performed the independent t-test on the post-test scores of Self-directed learning. To study this the following null hypothesis has been formulated.

- $H_0$ : There exists no significant differences between the mean scores Self-directed learning obtained in the post-test by experimental and control groups of students.

The above null hypothesis has been tested with independent t-test and the results are furnished in the following table.

Table 2: Showing t-values and p-values on the Post-test Scores of Self-Directed Learning of Experimental and Control groups

Dependent Variable	Group	N	Post-test		t-value (df=78)	Sig. (2-tailed)
			Mean	SD		
Self-Directed Learning	Experimental Group	40	85.45	10.931	2.911	.005*
	Control group	40	79.25	7.873		

\*-significant at 0.05 level

From the table 2, it is observed that the Mean and SD scores of Self-directed learning in post-test are 85.45, 79.25; and 10.931, 7.873 for the both experimental and control groups respectively. And also observed  $t(78) = 2.911$ ,  $p = .005 < .05$  when both the groups are compared. So, the obtained "t" value 2.91 is greater than the critical value 1.99 at 78 degrees of freedom and the "p" value less than .05 level of significance. Hence, the researcher has evidence to reject the null

hypothesis and alternative hypothesis has been accepted. This indicates that there is statistically significant difference has been observed in the mean scores of Self-directed learning of experimental and control groups in post-test. Which means that the Self-directed learning of students in learning physics is not similar in both experimental and control group after the intervention. From the table, the results reveals that the Self-

directed learning of students in learning physics of experimental group is higher than the control group.

**5.3. Analysis of the Impact of Concept Mapping on Self-Directed Learning of students in Learning Physics.**

In order to study the above objective “the impact of Concept Mapping on Self-directed learning of students in Learning Physics” the following hypothesis has been formulated.

**Hypothesis:** The students of experimental group will have higher Self-directed learning in physics when compared to the control group as a result of intervention.

For the purpose of testing the above hypothesis has been translated into null form.

**Null hypotheses:**

**H<sub>01</sub>:** There is no significant difference between the mean scores of Self-directed learning of students in learning physics obtained in the pre-test and post-test of experimental group.

**H<sub>02</sub>:** There is no significant difference between the mean scores of Self-directed learning of students in learning physics obtained in the pre-test and post-test of control group.

The null hypothesis has been tested with paired-samples “t” test and the results are furnished in the following table.

**Table 3: Mean, SD and t-values of Self-Directed Learning based on the Pre-test and Post-test of Experimental and Control group**

Group	N	Pre-test		Post-test		Mean Gain	t-v value (df=39)	Sig. (2-tailed) (0.05)
		Mean	SD	Mean	SD			
Experimental group	40	79.53	10.231	85.45	10.931	5.92	6.266	.000 <sup>*</sup>
Control group	40	78.23	8.725	79.25	7.873	1.025	0.877	.386 <sup>ns</sup>

From the table 3, it is observed that the mean and SD scores of self-directed learning of experimental group students obtained in pre and post-test are 79.53, 85.45; and 10.231, 10.931 respectively. And also observed  $t(39) = 6.27, p = .000 < .05$  when both scores of pre-test and post-test were compared. So, the obtained “t” value 6.27 is greater than the critical value 2.02 at 39 degrees of freedom and .05 level of significance. Hence, researcher has evidence to reject the null hypothesis and alternative hypothesis is accepted. Whereas in case of control group, the mean and SD scores of self-directed learning obtained in pre and post-test are 78.53, 79.25 and 8.725, 7.873 respectively. And also observed  $t(39) = 0.88, p = .39 > .05$  when both scores of pre-test and post-test were compared. So, the obtained “t” value 0.88 is less than the critical value 2.02 at 39 degrees of freedom and .05 level of significance. Hence, researcher has evidence to accept the null hypothesis. Therefore from discussion of these results, it reveals that the experimental group students who used

Concept Mapping showed more self-directed learning nature in learning physics when compared to the control group students.

**5.4 Covariance Analysis for Self-Directed Learning**

To determine if the differences in pretest scores might contribute to differences in posttest scores (i.e., the pre-test scores may have influenced the experimental effect), the researchers has been formulated following null hypothesis.

- **H<sub>0</sub>:** There is no significant difference in the mean scores of self-directed learning obtained in post-test for the two methods of learning physics ( $\mu_1 = \mu_2$ ).

In order to test above null hypothesis, the researcher has been performed an analysis of covariance (ANCOVA) by using pretest scores of self-directed learning as a covariate and the results are furnished below. All assumption regarding the analysis of covariance (ANCOVA) are satisfied including assumption of homogeneous regression slopes (by performing custom analysis, the interaction between Learn Method\*Pretest SDL is  $.618 > .05$ , indicating that the regression slopes are homogeneous).

**Table 4: Shows Means for the Two Methods of Learning**

**Descriptive Statistics**  
Dependent Variable: Posttest scores of SDL

Method of Learning	Mean	Std. Deviation	N
CMap	85.45	10.931	40
Conventional	79.25	7.873	40
Total	82.35	9.966	80

The table 4 shows that the mean and standard deviation of self-directed learning based on post-test scores for the two methods of learning physics. For the Concept Map, the mean

and SD are 85.45 and 10.931, for the Conventional method, the mean and standard deviation are 79.25 and 7.873 respectively

**Table 5: Shows Levene's Test of Equality of Error Variances<sup>a</sup>**

Dependent Variable: Posttest scores of Self-Directed Learning

F	df1	df2	Sig.
4.334	1	78	.061

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + PRESDDL + LearnMethod

The table 5 shows the results of Levene's test, it indicates that the assumption of equality of variances has not been violated, because .061 is greater than .05, meaning that we fail

to reject the null hypothesis, which states that the variances are equal.

**Table 6: Shows Results of Analysis of Covariance of Self-Directed Learning for Two Methods of Learning**

Tests of Between-Subjects Effects					
Dependent Variable: Posttest score of SDL					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1928.039 <sup>a</sup>	2	964.019	12.543	.000
Intercept	32253.758	1	32253.758	419.647	.000
PRESDL	1159.239	1	1159.239	15.083	.000
LearnMethod	684.005	1	684.005	8.899	.004
Error	5918.161	77	76.859		
Total	550368.000	80			
Corrected Total	7846.200	79			

a. R Squared = .246 (Adjusted R Squared = .226)

The table 6 shows F values, degrees of freedom, and significance levels for all main effects and the covariate. These results help to determine if there is a difference in the mean scores of self-directed learning for the two methods of learning physics after the pre-test is accounted for (i.e., after statistically removed the effect of pre-test).

Moreover, for pretest scores of self-directed learning the significant value is .000 less than .05, which indicates that differences in pretest scores might contribute to differences in posttest scores was correct. Hence, we reject the null hypothesis which states that pretest scores are not significantly related to posttest scores.

Further, the main effect for Learn Method is significant (.004 is less than .05), indicates that there was a statistically significant differences in the mean scores of self-directed learning obtained by post-test for the two methods of learning physics after adjusting for the effect of the pretest.

## 6. Findings of the study

- There is a significant impact of Concept Mapping on Self-Directed Learning of students towards learning physics ( $t(39) = 6.27, p < .05$ ) when compared

between the mean scores of Self-Directed Learning on pre-test to post-test.

- The Concept Mapping has shown significant impact in improving the Self-Directed Learning towards learning physics of the secondary school students ( $F = 8.899, p < .05$ ) when the pre-test scores of Self-Directed Learning taken as a covariate.

## 7. Conclusion

The study attempted to examine the impact of concept mapping on students' self-directed learning in physics of secondary school. The finding of the study has shown that there is a significant difference in the mean scores of self-directed learning of experimental group when compared to the students of control group from pre-test to post-test. These results indicate that the students of experimental group who used concept mapping for physics have improved their self-directedness in learning physics and become more self-directed learners than the students of control group who did not use. Thus, Concept Mapping helps the students to become as self-directed learners in physics.

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