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# The Effectiveness of Concept Map on Elementary Students' Creativity in Science Lessons

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**ABSTRACT:** Concept map is one of the teaching-learning strategies that can facilitate meaningful learning in students and show the relationships between the curriculum in a hierarchical manner. The present article has been developed based on research findings in which the effectiveness of concept map teaching on the creativity of elementary students in learning the concepts of the science lesson has been investigated. This study used a quasi-experimental pretest-posttest control design. The statistical population of this study included female school students, who were selected via accessible sampling and randomly assigned to the control and experimental groups. The research instrument included Abedi Creativity Questionnaire (1983). Data were analyzed by analysis of covariance (ANCOVA) using Spss22 statistical software. The results showed that the intervention based on the concept map was effective on students' creativity in science lesson by 63.8%. The results also indicated that the intervention based on concept map training has a positive and significant effect on the dimensions of creativity (fluidity, expansion, initiative, and flexibility).

**Keywords:** Education, concept map, creativity, science course, students, quasi-experimental.

## Introduction

Undoubtedly, science education is a significant part of school activities and the quality of science education, and the level of scientific and technological literacy of the people is one of the indicators of society development. In fact, the science course is very important like the other courses, and research has shown the weakness of Iranian students' creativity in the science course. The findings of Third Trends in International Mathematics and Science Study (TIMSS) in the field of elementary science show that the level of learning and creativity of Iranian students in science is very low (Ghasemi & Burley, 2019), and students without creativity in doing examination and solving exercises, try to do it. Creativity leads to problem solving, idea generation, conceptualization, artistic forms creation, theorizing, and novel productions, and is considered a fundamental factor in the development of societies; as scientific research has shown, creativity is a skill, so it is acquired and teachable. Therefore, it is possible to cultivate creative people by creating the necessary conditions, equipment and facilities. In this regard, the school is considered as a suitable place for teaching students' creativity (Gralewski, 2016). Actually; Creativity is one of the most important components of global competition in the 21st century. Increasing student's creativity is a major challenge for any educational organization. Education must be able to stimulate student's creativity. Through the process of learning, discovering and expressing creativity, anyone can be ready to compete globally. Education should be able to help students find and solve problems. The learning environment should be able to help students develop their creativity so that students can optimize their abilities. Students must be prepared to survive in real life. Thus, students need communication, practical, and creative skills. According to Jackson et al., creativity is a mental

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process involving the development of new ideas and concepts, or new relationships between existing ideas or concepts. From a scientific point of view, the product of creative thinking is usually original and adaptable. Creativity can be developed by exploring the relationships between the sciences. This relationship has many similar features such as development that should be understood and taught through education (Harjono & Sahidu, 2018).

In the present age, students have to improve their critical and creative thinking skills in order to make appropriate decisions and solve the complex problems of society in the period of amazing developments of the third millennium AD. They need to develop research skills, problem solving and a search spirit. It is clear that in order to achieve these goals, educational centers will be endowed a great responsibility. On the one hand, these centers are responsible for educating students and equipping students with the information they need, and on the other hand, they must provide the ground for the growth and development of creativity, innovation, and proper use in today's world for talent and ability cultivation (Salı, 2019). Regarding the fundamental role of creativity in life, it is essential that valuable ability be nurtured in children, and the factors identified, because strengthening creative thinking is essential for the current and future development of the child and society. Creative power and creative thinking of people in society is an important factor in the development of society, and we must look for programs that develop this ability in them (Salı, 2019).

Thus, the development of creativity is increasingly seen as a necessity in the field of education, because creativity can motivate students to perform better and affect their future success. In fact, most teachers find students smarter when they can retrieve, remember, and apply information opposite to creative perspectives. Inflexible classroom rules and rigid learning environments can also deter students from thinking creatively (Castillo-vergara, Galleguillos, Cuello, Alvarez-marin, & Acuña-opazo, 2018).

Indeed, of the many important skills that students must master in order to survive in the present century, creativity is the most important (Castillo-vergara et al., 2018). Creativity involves trying to find unknown, creating new solutions to every problem we face and bringing things together in a new and different way. Creativity generates new, diverse and unique ideas and is part of 21st century skills that must be empowered through learning. In fact, creativity plays an essential role in the development of human civilization and influences human lifestyle (Wang, Chang, & Li, 2008). This has social and economic consequences and a positive effect on the personality aspects of individuals. By fostering creativity over the years, education can create an imaginative thinking community (Chu, Reynolds, Tavares, Notari, & Lee, 2021).

Therefore, if a student wants to apply his / her knowledge and be creative, he / she must first acquire skills at the level of memorization and comprehension in order to be able to perform better at the level of application, and this will not be possible unless the student can learn the lessons coherently and in relation to each other. Therefore, in education based on creativity, educational techniques and various methods have been used and operated by specialists and experts in scientific, industrial and educational circles for many years. One of these theories that has been considered in recent years is the theory of structuralism and its method is concept map.

The theoretical framework of the teaching method of concept maps is based on the meaningful learning of Ausubel (Mesrabadi & Alilou, 2016). Concept map is a graphic tool that is used to show the



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knowledge and learning of students. It is composed of concepts and links the concepts. Concept maps help to understand, organize and structure information. Graphic structures, like a concept map, are closer to the macro structure of the text, making it easier to understand. In addition, mapping allows students to process concepts continuously (Reiska, Soika, & Cañas, 2018). Concept map is a tool to show the relationships between concepts in coherent, organized way and a new method in education that is rooted in Ausubel's theory of meaningful verbal learning and the pre-organizing concept (Hasanpour & sheikhzadeh, 2018). In fact, a concept map is a graphical representation of how one concept relates to another concept, as well as how they relate to other concepts related to a particular topic. Concept mapping is therefore one of those strategies that enables learners to reflect on the connections between what is being learned, to organize their thoughts, to visualize the relationships between key concepts in a systematic way, and to understand and ponder about them. Therefore, in the concept map, students learn new materials with emphasis on previous learnings and each concept is connected to another concept by the connected words (Taghizadeh, Fathiazar, & Azarbakhsh, 2018).

In fact, a concept map has been a way to show the relationships between concepts graphically. It consists of several elements identified by labeled nodes, connections between nodes (referred to as connections below), and propositions. Concept maps typically use a hierarchical approach to express relationships between concepts, such as leader-member relationship and solidarity, and they have a wide range of programs in educational areas. Depending on the application scenarios, it can be divided into two types of tools: teaching assistant or evaluating the quality of teaching.

As a teaching assistant, a concept map cannot only help teachers improve their teaching ability and teaching effectiveness, but also help them develop educational activities such as course design, teaching design, knowledge building, and more (Pailai, Wunnasri, Yoshida, Hayashi, & Hirashima, 2017). In addition, it can be used to improve learning effectiveness and efficiency as a learning skill. On the other hand, as a tool for teaching and learning performance evaluation, concept maps can be used to provide an appraisal model that can measure learners 'understanding of the structure of knowledge and the relationship between concept points and learners' learning performance to evaluate effectively and comprehensively. A concept map is skilled in using a number of diagrams and colors to illustrate the characteristics of concepts and to reflect what is called "dual coding theory": that is, recognizing the human process of delivering linguistic and non-linguistic objects. Compared to traditional methods of evaluating the effect of learning, the concept map has many advantages. Thus, the concept map has become a comprehensive tool for evaluating education, and has wide applications in the field of formative evaluation (Huang, Lin, Yuan, & Chen, 2020).

One study has found that fifth-grade students who developed a concept map had higher post-test scores after two weeks. Another study, also involving fifth-grade students, has found that those who used a concept map to visualize an electronic portfolio are students who visualize the same portfolio through a tree structure after three days (Furtado, Hirashima, & Hayashi, 2018). Therefore, concept maps are a tool for organizing and representing knowledge. Their components include new concepts enclosed in circles or boxes, creating hierarchical arrangements between concepts and sub-concepts, and defining the relationships between concepts and sub-concepts with a connecting word on it. In fact, concept maps

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have been used as teaching and learning strategies to help students represent and organize their knowledge (Si, Kong, & Lee, 2019).

Concept mapping techniques are tools that are widely used by researchers to assess the structure of students' conceptual knowledge. Thus, the concept map is a graphical tool for organizing and structuring knowledge in teaching, learning, and assessment introduced by Novak and Gwyn. As a powerful and flexible learning tool, the concept map approach can be used separately or jointly in different disciplines and for different purposes. Concept mapping is now widely accepted as a tool for measuring student's knowledge and is increasingly embedded in computer environments. Computer-based conceptual mapping allows students to organize their knowledge easily (Prasetya, Hirashima, & Hayashi, 2020). In fact, concept maps help students visualize their learning. Concept maps are specifically recognized as a constructivist tool that facilitates active, reflective, and meaningful learning. Many examples in library texts testify that it is valuable to encourage students to visualize research, brainstorming keywords, and subject ideas using mapping tools (Samie zafarghandi, 2014). Thus, a concept map is a tool for displaying information in the form of interconnected diagrams and boxes in which the logical connection between concepts is clearly visible as a kind of visual representation of meaningful relationships between concepts (Lestari et al., 2019). The concept map is usually set from whole to part, and it has core, relation and node parts; that is, more general and comprehensive content is at the top, and the closer we get to the bottom of the map, the more detailed the concepts and content. In drawing concept maps, nodes are usually placed inside the box and relationships are written on the connecting lines. Therefore, a concept map is a tool for describing key ideas and concepts related to a subject in the form of a graphic form (Tuan, 2011).

Therefore, creativity and its cultivation is an issue that is not taken into account in our education system and its great importance is ignored. Undoubtedly, part of the inefficiency of this system is related to this shortcoming and negligence. Therefore, it is obligatory on education planners and education officials from the lowest to the highest levels to eliminate this shortcoming, especially in the kindergarten and primary education system, and this issue should be attended. Because creativity is a trait that in the first years of life can be nurtured and fertilized in the best possible way, and basically a large part of the child's personality is formed in the first 6 years of life. A period in which a child increases his or her understanding of the world around him or her, learns language, and gradually acquires other abilities. Therefore, creativity is one of the prominent features of man and one of the great processes of his brain which plays an important role in shaping the personality and character of the child and his future, so it is necessary to know this valuable trait well and make every effort to nurture it in the child (Sternberg, 2018). Without creativity, human growth is not possible. Creativity is a competence that can be improved or influenced in a timely manner by the environment and personal activities (Azimpoor, Eisavi, & Azimpoor, 2017).

Azimpoor et al. (2017) in their research show that using teaching-learning strategy concept map in science teaching is effective in increasing creativity and increasing fluid components, initiative and development. The results of internal and external research show the importance and application of concept maps in the level of students' learning in different fields of education. Although much research has been done on creativity and its related and influential factors, many aspects of it still remain



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unknown. Therefore, considering the importance of this issue, the purpose of this study is to answer the question of whether teaching concept map in science teaching has an effect on students' creativity and self-actualization or not.

**Research hypothesis**

How effective is concept map teaching on the creativity of elementary students in learning the concepts of experimental science?

## Material and Methods

The present study is descriptive and quasi-experimental based on the applied purpose, nature and method of research. The design used in this study is one of quasi-experimental designs, pre-test and post-test design with control group. In this way, the samples will be pre-tested; then the experimental group is affected by the independent variable which is a concept map in this study and the control group does not receive any intervention. At the end of the training sessions, post-test is performed for both groups. These two groups are randomly selected and their assignment is random.

**Table 1**. Executive model of research

| Group | Number | Pre test | Independent variable (concept map based training) | Post test |
|---|---|---|---|---|
| E | 15 | T1 | X1 | T2 |
| C | 15 | T1 | - | T2 |

E :Experimental group, C: control group, T1: pre-test, T2: post-test

As can be seen in the table above, the subjects are randomly selected (R) and assigned to the experimental group (E) and the control group (C). All groups undergo pre-test (T1) and post-test (T2). The subjects in the experimental group receive an intervention (concept map-based training) (X1) but the control group does not receive any intervention and undergo pre-test and post-test.

**Society, statistical sam**pling and sampling method: The statistical population of the present study consists of female students in the third grade of elementary school in Sanandaj, Iran in the academic year 2020 which are selected purposive and randomly assigned to the control and experimental groups. In this study, 15 people in each class are selected as the experimental group and the control group, and after a full explanation of the research and their satisfaction, the experimental group start training course for 120 minutes for 2 sessions per week. All subjects complete the research tools in both pre-test and post-test**.**

**Measurement tools**

**Teacher-made academic achievement tests (pre-test and post-test):** The present study has pre-test and post-test. The pre-test is all the contents of the third grade experimental science textbook (the whole textbook) which is selected as an accompanying variable. The post-test is one of the subjects taught in the book of experimental sciences of the third grade of elementary school (in 12 sessions) with the concept map method and conventional methods. The academic achievement test is prepared from the mentioned content in the form of four-choice questions of science course at different levels of cognitive domain based on the specifications table. 20 questions of this test are included in the pre-test and 20



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questions in the post-test. The pre-test and post-test questions are almost identical in terms of content and difficulty. To determine the content validity of the test, experts' judgments are used to the extent by which the test questions represent the content and objectives of the program. To ensure the content validity of the test in the process of making them, a table of specifications and opinions of supervisors, counselors and experienced teachers is used, and after reviewing and removing ambiguous and unfamiliar items, it is implemented. The number of questions is the same for each concept and educational level, but the form of questions in the pre-test and post-test is different.

**Table 2**. Reliability of pre-test and post-test questions

| Test | Question number | Standard deviation | Mean | Reliability |
|---|---|---|---|---|
| Post test | 20 | 4.52 | 20.7 | .72 |
| Pre test | 20 | 4.93 | 15.2 | .74 |

As shown in Table 2, the reliability of the pretest is.72. In this table, the reliability of the post-test is also seen as.74. Content validity and criterion validity are used to assess the validity of pre-test and post-test. For this purpose, a pre-test specification table (third grade natural science book) and a specification table of the taught materials during the research are prepared.

**Creativity Questionnaire**: Abedi made a 75-question test based on the Torrance test in 1984 and standardized it on 650 third year middle school students in Tehran. The current test form was revised by Abedi and two other professors at the University of California in 60 items (22 items in the fluid section (from question 1 to question 22), 11 items in the expansion section (from question 23 to question 33, 16 items in the initiative section (from question 34 to question 49), 11 items in the flexibility section (from question 50 to question 60). The reliability of the fluidity, initiative, flexibility and expansion are.75, .67, .61, and .61 respectively.

To conduct the research, the text of the third grade elementary science textbook is considered as educational materials that include the concepts of foods, materials around us, measuring materials, water, valuable materials, our life and water, light, observation of objects and forces. Concept maps are prepared based on the textbook and professors and teachers' experiences. These maps are used to teach and present content as well as to summarize. In preparing the concept maps, an attempt is made to observe the simplicity, mentality and hierarchical brevity of the contents of the concept map. The concept map training method is implemented in the form of the following five steps: 1- Preparation stage, 2- Concept map preparation stage, 3- Pre-test stage, 4- Execution stage, 5- Post-test stage.

Preparation stage: in this stage, the preparations for the experiment are arranged. After identifying the samples, they are first given the necessary explanations about the concept maps and how to prepare them in two 11-minute sessions for teachers who should teach with a concept map.

Concept map preparation stage: In this stage, concept maps are prepared for each of the selected textbooks using Smart Ideas software, and after reviewing and consulting with teachers, the concept maps are printed on A4 and A3 papers.

Pre-test stage: in the first session of the experiment, the test (pre-test) is given to all groups without prior knowledge of the students' previous content and learning.

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Execution stage: the duration of this study is 12 sessions of 20 minutes. In these sessions, at first, before teaching, the teacher presents the prepared concept map in front of the students, and in the pre-teaching stage, the maps as a pre-organizing tool, in the teaching stage, is a content presentation tool, and in Post-training stage maps are used as a tool to summarize and integrate the lesson (Mesrabadi & Alilou, 2016).

Post-test stage: in the last session of the experiment, the subjects learn from the materials taught during the research without prior notice (post-test).

## Results

Descriptive indicators of research variables are presented in table 3.

**Table 3**. Descriptive statistics of pre-test score, post-test of creativity in control and experimental groups

| Variable | | Pre test | | Post test | |
|---|---|---|---|---|---|
| | Group | Mean | Standard deviation | Mean | Standard deviation |
| Fluidity | Experimental | 34.52 | 7.65 | 41.86 | 8.43 |
| | Control | 36.63 | 6.98 | 34.38 | 6.29 |
| Development | Experimental | 41.53 | 9.75 | 52.36 | 7.96 |
| | Control | 46.36 | 9.64 | 49.47 | 7.86 |
| Creativity | Experimental | 23 | 5.38 | 28.23 | 4.36 |
| | Control | 22.58 | 3.92 | 20.53 | 3.15 |
| Flexibility | Experimental | 31.47 | 7.85 | 36.68 | 6.42 |
| | Control | 29.63 | 3.63 | 38.68 | 3.12 |
| Total creativity | Experimental | 130.53 | 30.63 | 159.15 | 27.17 |
| | Control | 134.90 | 24.18 | 133.07 | 20.43 |

As can be seen in Table 3, the average score of the experimental group in the Creativity Questionnaire in the pre-test is 130.53 and in the post-test is 159.15. Also, the average score of the control group in the Creativity Questionnaire in the pre-test is 134.90 and in the post-test is 133.07. The results of the above table also include the scores of the experimental and control groups in the dimensions of the Creativity Questionnaire (fluidity, expansion, initiative, flexibility).

### Examination of statistical assumptions

The analysis of covariance requires the observance of statistical assumptions, which are examined under each of these assumptions, and the results of the study indicate the appropriateness of this test to analyze the research data. We tested the linearity of regression, homogeneity of error variances, equality of covariance matrices, independence of error terms and homogeneity of regression slopes and there was no violation of them.

The normal distribution for the scores of the variables is done through this test. In this test, if the significance level for the variables is greater than the test level (.05), the data distribution is normal. As the results show, the significance level of Kolmogorov-Smirnov and Shapiro-Wilk test for the creativity variable is greater than .05. As a result, these variables studied in the present study have a normal distribution.

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**Table 4**. Kolmogorov-Smirnov and Shapiro-Wilk test to examine the creativity variable data distribution

| Variables | Kolmogorov-Smirnov test | | Shapiro Wilk | |
|---|---|---|---|---|
| | Test statistic | *p* | Test statistic | *P* |
| Fluidity | .13 | .20 | .92 | .26 |
| Development | .16 | .20 | .94 | .55 |
| Creativity | .15 | .20 | .91 | .12 |
| Flexibility | .16 | .20 | .93 | .43 |
| Creativity (Total) | .13 | .20 | .96 | .74 |

**Examine of research hypothesis:** How effective is concept map teaching on the creativity of elementary students in learning the concepts of experimental science?

In examining this question, an educational intervention based on a concept map on students' creativity in learning science through multivariate analysis of covariance is used, the results of which are shown in the table 5.

**Table 5**. Results of MANCOVA on the average score of creativity dimensions

| Index | Value | F relativity | DF error | DF Hypothesis | *p* |
|---|---|---|---|---|---|
| Pillai's trace | .85 | 16.08 | 23 | 3 | .001 |
| Wilks' Lambda | .15 | 16.08 | 23 | 3 | .001 |
| Hotelling's trace | 5.67 | 16.08 | 23 | 3 | .001 |
| Roy's largest root | 5.67 | 16.08 | 23 | 3 | .001 |

Table 5 shows that there is a significant difference between experimental and control groups in terms of creativity variable at the level of .001. Accordingly, it can be stated that there is a significant difference between the two groups in at least one of the dependent variables (dimensions of creativity). To find out the difference, multivariate analysis of covariance is performed and the results are listed in Table 6.

**Table 6**. Results obtained from multivariate analysis of covariance on post-test means of experimental and control groups

| Variable | Total squares | df | squares mean | F value | *p* | Effect size |
|---|---|---|---|---|---|---|
| Fluidity | 23.38 | 1 | 23.38 | 29.26 | .001 | .41 |
| Development | 12.24 | 1 | 12.24 | 17.71 | .004 | .38 |
| Novelty | 38.74 | 1 | 38.74 | 69.74 | .002 | .34 |
| Flexibility | 5.86 | 1 | 5.86 | 4.30 | .001 | .65 |
| creativity Total | 14.56 | 1 | 14.56 | 20.51 | .001 | .63 |

As can be seen in Table 6, the F of the comparison of the mean of the overall score of creativity of the two groups is equal to 20.51 and is significant at the level of .001. Considering the amount of effect size, the rate of intervention based on concept map teaching on students' creativity in science course is equal to 63%. Also, according to the amount of effect size, the greatest effect of concept map training on the dimension of creativity (flexibility) is 65%. Also, the lowest effect size of concept map training on the dimension of creativity (initiative) is .34%.

## Discussion

Studies and observations on conventional teaching methods in schools show that despite the relative attention to the subject of concept maps in teacher's changed handbook and textbook, a large number of teachers still use graphic maps. They do not use a concept in their teaching and do not seem to be aware



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of its effect on students' learning. The aim of this study is to help teachers in the science course in choosing a more desirable teaching method with greater efficiency. In this research, the effectiveness of using a concept map in teaching science on students' creativity has been investigated. The results of the present study show that in the concept map method, when students focus on one topic, they realize that there are many connections between concepts; so, in choosing these concepts and expressing the relationships between them, they face mental challenges and this in itself leads to the flourishing of creativity and deeper learning. It is also found that the organizing factors of the concept map make the concept map method superior to the lecture method. Because a concept map as an organizing strategy allows the learner to write the main and sub-ideas briefly and using important words and phrases, this organizing strategy turns the text into a plan or map .On the other hand, creativity has several aspects, each of which must be examined in its place. A very important aspect of creativity is the existence of the necessary conditions for the emergence of this universal talent. Therefore, for the growth of creativity and innovation in students, education must reach a correct and clear understanding of the current situation and in the next step, based on the philosophy of education, principles and valid scientific criteria, a clear picture of the situation draws creativity. In this way, with the least amount of time, energy and capital, it can pave the way for cultivating and flourishing students' creativity and innovation. Therefore, one way to cultivate and develop creativity is to draw concept maps by students in courses such as science. Because in elementary courses, each teacher teaches in only one class, so the characteristics and way of thinking and in the whole scientific and social personality of the teacher can affect the academic achievement of students. Based on the research findings, it can be suggested to curriculum designers and authors of experimental science textbooks to consider the use of concept maps in curricula and textbook content. Teachers can also use the concept map as a teaching-learning strategy and nurture students' creativity at various stages of teaching and assessment, and encourage students to use it as a learning strategy. Given that maps can play a pre-organizing role, it is suggested that chapter-related map science textbooks be delivered at the beginning of each chapter and that students be taught conceptual map drawing skills from an early age. It is also suggested that curriculum planners and textbook authors make more use of concept maps in writing books and teacher's guides. Finally, school principals are advised to provide the necessary conditions and physical facilitation as well as spiritual support to teachers to implement the educational strategy of concept map and the application of diverse and new educational strategies, which increases the creativity of students; it can be considered as one of the evaluation criteria for teachers.

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