

## **The Use of Information and Communication Technology Application on Graph Theory Education**

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**Abstract:-** In order to study the effect of information and communication technology on math learning from two classes of mathematics, students in Mazandaran teachers' university (Dr. Shariati Campus, Sari, Mazandaran, Iran), one class was selected as an experimental group and the other as a control group. The graph subject in the lesson discrete mathematics was taught to the experimental group by using NEWGRAPH educational software that is a kind of dynamic interactive software and the same subject was taught to the control group without this software. At the beginning of this course, a pretest was applied and at the end of it, a post test was held. The results of using unilateral covariance analysis indicated that the experimental group's scores were better than those of the control group in the significance level  $p < 0.05$ . This research, also, is going to answer the following questions: To teach mathematics, should teaching totally be done by using modern technology and/ or combination of the other teaching methods, and which strategies can we use except or better than technology?

**Keywords:-** information and communication technology, educational software, math learning

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### **I. INTRODUCTION**

Different methods have been used in math education during history. Most of researches about the role of technology in math education frequently have been dealt with general advantages of technology. In this paper, some advantages of technology combination in math education and especially two important advantages such as visualization and feedback, while using computer are studied. Some of the teaching patterns which can be adopted regarding to the advantages of technology combination without using technology will be represented according to the result of quantitative and qualitative analysis. In order to use technology in math education comprehensively and its new and different application, Kimmins states the role of technology to help the development of mathematical skills and concept in problem solving, growing mathematical arguments and relationships. [1] Also, Aminifar suggests different application of information education communication technology which can help math education as fast feedback providers for students and tools of accurate and fast visual presentation of mathematical forms in order to use these forms by students and opportunity to show their effects. Then, he introduces educational technology as a help for those calculations that cannot be done by hand and their main objective is not calculation skills. [2]

Although, different aspects of information technology have been emphasized frequently, teachers should guide and support students. The use of technology in math class should not lead to technical confusion and limitation. Students should use the tool to facilitate the creation of mathematical objects, to make mathematical exercises on the objects possible and to provide an absolute reason of those exercises' consequences. [3]

One of the most important advantages of using computer in math education is multiple representation and feedback by using computer.

Multiple representation and visualization by using computer: the role of technology in math education and multiple representation and visualization by using computer have been focused by different researchers. Valinejad et al have emphasized the significance of visualization in math education. They believe an image is more valuable than one thousand words, thus, they stipulate the role of visualization-based education in accurate, fast and explicit questioned concepts. [4]

Mathematical tendency subjects as cognitive tools can reduce tasks through doing less important components, therefore, strengthen high-order thinking and hypothesis testing and create high degree of mathematical and cognitive fidelity which is provided with technology while making representation. Multiple representations of math objects can strengthen the relationship among different math concepts and deepen students' learning.

Serpil et al define visualization as an act in which one makes bilateral representation between internal structures and some external factors. An act of visualization consists of any imagination of object or events by an external source.

Similarly, visualization can have a structure depend on some external media such as objects or events. Also, visualization is translation and transfer from out to mind. It is a useful method and powerful source for students to do Mathematics. This method is beyond different thinking methods in Mathematics that results from predicative and linguistic logic thinking, symbolic and traditional use of old algebra.

Visualization approach prepares students to study math objects that are group of abstract structures and concepts in different perspectives. [5] Visualization is processes, data, organizational structures, places, sequences, generalizations, theories, emotions and attitudes. Visualization methods range changes from emphasizing diagram in text by coloring to create a completed diagram and nonverbal presentation.[6] It is said that for example scientific Visualizations in classes are providing information with new methods for acceleration students' perceptions. These Visualizations may include simulating a scientific rule for new classification of information that clarify scientific explanation elements or a new method for organizing data (for example, using colors as heat index). Visualizations use theoretical symbols of color, sing and sound to help students to recognize elements to perceive its results. Also, the acts similar to reality of simulation that sometimes can be used for hypotheses testing and problem solving are useful. [7] Visualization causes perceptions of different events even by a glance.[8]

Conception of visualization may differ from related observation. For instance, when the teacher draws an incomplete circle on the board that is not a circle, because the circle is not drawn completely. Of course for one who knows a circle is a set of points at page they are in the same distance from center, the image on the board is enough to make understanding for the teacher is speaking about " Mathematical circle ". Yet, for the student who knows nothing about circle concept previously, the image on the board may have other meanings, so visual imaginations are enough to convince oneself absolutely, if one have enough knowledge about something which is shown [9] .The advantages of using Visualization and multiple representation in math education can realize better by computer.

Even though in some mathematical subjects, visualization and intuition is not possible without using computer and educational software. Computer is the main tool for mathematical research and application. Computer software can provide mathematical objects Visualization easily. If there is no such visualization and presentation, learning will become even harder [10], above subjects that emphasize the significance of mental Visualization and imagination by using computer.

## **II. COMPUTER FEEDBACK**

Computer feedback and interaction and dealing with Mathematical subjects by using computer have strong effect on students' learning. Feedback is a reaction to students' learning behavior and includes verbal and nonverbal reaction' for example' mentioning. Attracting attention and proposing are next steps [11].

Computer is used to extend human mental abilities. Computers are flexible and can provide feedback according to learner's speed and ability. Also, they can implement these teaching methods which have been presented by human mind proficiently i.e., give feedback to learner's errors results in his/her learning. So Computer software should be presented to different learners.

Computer can expand the size of teaching aid tools [12].It is said that representing feedback to students in order to make him/her aware of his/her errors in problem solving results in correcting incorrect knowledge that the student has in his/her mind. Students retain the correct and incorrect information which use to solve problem in their mind [13]. Seemingly, correcting Student's incorrect mental knowledge through on time and accurate feedback is an appropriate method for successful and creative students in math education is important, too. Although, receiving feedback from peers and the teacher can be effective, but the interaction characteristic of learning environments based on computer facilitates students' self-awareness about misunderstanding and lack of knowledge among the same-age learners and correct their previous knowledge, also [14].

**Computer feedback kinds are classified as follows:**

- Knowledge of result (KR) means a kind of feedback which states whether a solution is correct or not? For strong students, knowledge of possible result is minimum feedback.
- Knowledge of correct result(KCR) that present correct solution. This method is suggested for students with little previous knowledge, low ability, many errors and relative simple learning objectives.
- Answer until correct (AUC), asks students try to find correct Answer. This method has been recognized for students with sufficient abilities to exercise and to do valuable complicated works.

Instruction-based elaboration (IBE) includes an interpretation of correct solution, local errors correction or representation of main guide [11].

Technological environment are designed purposefully to develop interaction, experiment, further observation, correction and implementation. Hypothesis are active components which are used to make relation and improve arguments, therefore, it is necessary to apply proper educational technology according to right educational principles [3].

This research is going to determine the effect of technology on math learning. The most popular applied technology in math learning is educational software, so, in this research, NEW GRAPH educational software that is kind of dynamic interactive software is used as a technological tool. The graph subject of discrete Mathematics in math undergraduate (that less research is done about educational software technology in this lesson than other math branches) is taught as a math subject, too. The main hypothesis and question of this research are as follows:

Hypothesis: the use of NEW GRAPH educational software has effect on students' conceptual perception.

**Question No.1:** what kinds of suggestions can be presented for teaching without educational software according to this research?

**Question No.2:** whether graph theory is taught by using only educational software or the combination of other educational methods is necessary?

### III. RESEARCH METHODOLOGY

Research method and design: From statistical society of undergraduate students of Mazandaran teachers' university, one class was selected as an experimental group and the other as a control group. In this research, available sampling method is used. Independent variable is the use of educational software that is applied for experimental group. Research design is pretest-post test design with control group (unequal control group design) [15].

In this research, quantitative and qualitative methods are used. Qualitative method includes interview, open-answer questionnaire, class observation, study students' journals, study of outlines of graph subject in discrete mathematics in comparison with the mentioned subjects regarding to this in mathematical principles and standards book at universities.

Quantitative method indicates covariance analysis of numerical results of written scores average of lessons that are prerequisites of discrete mathematics and post test scores are related to teach subjects to both groups after the course.

The researcher made tests consisting of pretest and post test. The content validity of the tests is confirmed by several math professors and experts. To study the reliability of pretest and post test questions, these tests are implemented in a class except the control and experiment groups after 20 days. Final coefficients for pretest and post test are 0.91 and 0.93 respectively.

Implementation: The two groups are taught a graph subject two sessions in a week and for four weeks. The graph subject of discrete mathematics in undergraduate includes concepts like definition, order, size and degree of graph, regular, complete and empty graph, road and cycle of graph, connected graph, Oiler and Hamilton graph, tree and matrix and theorems including "sum of vertices degrees is even", "the number of odd vertices is even", "there is a direction between every two vertices of a tree precisely" and other theorems and different definitions. In teaching both groups, it is attempted to use proper educational methods to increase conceptual perception. The same teaching method has implemented for both groups according to educational theories.

### IV. DISCUSSION AND RESULTS

Result of study and hypothesis of research: The hypothesis of research was "the use of NEW GRAPH educational software has effect on students' conceptual perception." In order to study hypothesis of research, covariance analysis method is used. This method studies the effects of one or several independent variables on a dependent variable and on accompanied variable as an effective variable on dependent variable.

**Table 1 .Levin test, the dependent variable of post test**

Significance level	Degree of freedom Second group	Degree of freedom First group	F
0.77	16	1	3.584

Levin test has shown the homogeneity of variances in both experiment and control group. The evaluation of balance zero hypothesis between every accompanied variables and independent variable has

shown F related to balance of educational background is not significant ( $F=0.071$ ,  $p>0.05$ ), then balance zero hypothesis is adopted for educational background and independent variable.

Also, F related to pretest scores is not significant ( $F=0.021$ ,  $p>0.05$ ), then zero balance hypothesis of pretest scores with independent variable is adopted and so covariance analysis is used.

**Table 2 .covariance analysis calculations in brief is seen in the table 2,**

source	Sum of squares	Degree of freedom	Average of squares	F	Significance level
Educational background score	2.384	1	2.384	0.278	<b>0.606</b>
Pretest score	1.202	1	1.202	0.142	<b>0.712</b>
Independent variable	65.630	1	65.630	7.759	<b>0.015</b>
error	118.416	14	8.458		
sum	3685.938	18			
Corrected sum	206.767	17			

The significant level of independent variable is equal to 0.015 ( $p>0.05$ ). Since the significance levels of educational background score and pretest score are 0.606 and 0.712 respectively and both are more than 0.05, therefore, these two variables have not much effect on dependent variable (post test scores). It is said that the two above variables did not affect post test scores and only the use of educational software in experimental group increased post test scores. Thus, the research hypothesis is confirmed and it can be said that the use of NEWGRAPH educational software has effect on students' conceptual perception of graph theory.

Answer to research questions: what kinds of suggestions can be presented for teaching without educational software according to this research? To use technology and its advantages can bring some teaching strategies to us, if we don't use technology, the ideas are resulted from the use of it can be used. The advantages of the use of computer in math education which are stated by students are feedback speed and dynamism. Here, how to combine these advantages in education without using computer is propounded.

Feedback: the advantages if using computer which are mentioned by students in their interviews were the fast feedback they received from computer. Seemingly, if it is possible to represent sufficient feedback to students, we can use this advantage of computer without using it in the class. To do this, we can put students into groups and ask them to give feedback to their friends' errors in problem solving and if they couldn't judge the solution which is used by them they can depend on teachers. The teacher guides their discussion in order to prevent them from doing wrong.

If problem solutions are proposed by Seinfeld and Polia is implemented accurately and completely, correctness or incorrectness of answer can be checked by student himself or herself. For example Seinfeld considers sources, strategies and control and beliefs systems as necessary aspects of problem solving and interprets control as a tool to examine the correctness or incorrectness of the applied procedure. Problem solving steps stated by Polia include problem understanding, planning, plan implementation and regression. In addition to emphasize control solution in each four steps, Polia states answer in the regression step that checking is seemed to give feedback to students in each step, especially the last step partially but not as accurate and fast as computer or even peers and teacher [14,16].

Speed: to consider classes indicates that calculations which have not much effect on understanding the related problems and subjects are much time consuming. Of course these solutions are not useless completely, but rather to time spend on them, they are not efficient. This situation has been experienced by researchers in classes and other professors' discussions who confirm this subject. If there is no computer, we can put students into groups. In this method, each group can answer a problem and present its result in class which increase learning in addition to students' learning speed, activities and involvements in groups. Computer is superior to human because of speed and accuracy in all of its application. We can form an idea of this advantage partially and reduce students' tiredness of energy consumption for repeating procedures by eliminating unnecessary calculations in the class.

For instance, drawing forms is one of the problem solutions and at least form an idea to represent a solution in graph subject. We can present more forms than those are in textbooks currently in order to students don't spend time on drawing forms or about permutation and combination calculations which are used in graph

subject, we can give some example of solution of this subject to recall what students learnt before and use those answers that have been prepared before and use calculator.

Dynamism: the form of applied software indicates that students could move created vertices and or sides easily and observe their changes. Dynamism in research about dynamic geometry software is a proper method to learn geometric subjects and graph is described as geometry regardless of size. It will use this proper educational method as dynamic representation. This research results confirm students' deep learning for teaching graph as a dynamic subject. Those students who have drawn graph by hand and have taught the transposition of vertices and sides of graph subject have described the graph as more fantastic subject with more application in addition to learning attractiveness in comparison with the students in control group. Although to teach graph subject in class dynamically without computer is hard, but we can use dynamic advantage of graph in teaching. For example, we ask student draw different forms of a graph and state adjacency matrix and other features students learn graphs with different forms but the same features such as adjacency matrix and the number of vertices, sides and vertices degrees are considered as one graph.

Whether graph theory is taught by using only educational software or the combination of other educational methods is necessary?

According to this research result, not only educational software should use to teach, but also other educational methods like class question and answer, lecture problem solving without computer and other proper methods should use.

Research results indicate that students' post test scores in experimental group is better from students' post test scores in control group significantly. Interview with students and class observations clarified that students could not understand the process solution completely or some of them expect teacher or other classmates to describe them orally. There are students with different learning styles characteristics in classes. Huang et al express a kind of grouping students and different learning styles by students:

Independent students prefer educational materials in proportion to their individual speed and study and tend to individual work rather than work with other students on lesson projects.

Dependent learners consider their teacher and peer as guide authority and prefer an authority tell them how to solve problems.

Competitive learners try to play role better than their peers and receive confirmation for their educational knowledge.

Collaborative learners, acquire knowledge through participation and Collaboration.

Avoidant learners do not participate in class activities and discussions motivationally.

Participant learners are interested in class activities and discussions and desired to take part in class activity as much as possible. They are exited strongly to meet professor's expectation and prefer to give lecture in small group discussions and group projects.[17]

To use only educational technology without combining with other teaching and learning methods can not satisfy students with different learning styles and cannot cause their better learning. To use different teaching methods in class can help student's learning with different abilities.

Give students alone with computer even equipped with most advanced educational software is not a wise educational method. Human and social communications rule over classes that are expressed under the title of communication standard in university mathematical principles and standards, it is an important feature that will be destroyed by using technology only.

The educational materials and subjects, especially social and moral characteristics that are learnt by students from their peers and teacher never can be substitute by any kind of technology.

It can be said that although computer has features that are necessary in math education, but they are not useful in this educational research and prevent from class discussion and exchanging views. To use computer, we should consider it not only as a factor of success but also we should consider educational environments and the most important thing is their proportion to students' literacy and skill.

Therefore, classes with different educational conditions and students with different educational backgrounds require different methods to use technology and education and to use technology is not the only factor of success and if we don't consider other conditions and factors maybe it obstacle other proper educational methods.

## **V. CONCLUSION**

Speed in proportion to each student's learning and fast learning without using computer and dynamic mathematical forms which facilitate visualization and make multiple representations of mathematical subjects possible are the advantages of teaching with software such as feedback and students' interactions with computer. We should take into account advantages and disadvantages of using technology and try to minimize disadvantages and emphasize the advantages. In this research, some advantages of a kind of dynamic interaction

are taken into account which is an appropriate technology in math education and some suggestion and strategies are presented to use and emphasize these advantages while we don't use technology. Researches about using other technologies in math education will clarify more aspects of technology effects.

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