Study on the Effect of Crocodile ICT 605 Software on Mathematics Learning for Teaching Flowchart Based on Constructivism Theory

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Abstract
Nowadays, one of the most important issues which have drawn the attention of educational planners is how education system should face the opportunities and threats arising from development of information and communication technology so as to make the best use of them. Teaching and learning mathematics by help of information technology is a modern approach. This paper attempts to study the effect of using Crocodile ICT 605 software in teaching flowchart, based on constructivism and in line with behavioral goals, on progress of students in mathematics. For this purpose, 55 girl students of the third year of high school in the field of mathematics in Tehran were selected by quasi-experimental method. The results obtained by the above mentioned software and teacher-made test as well as statistical results (with significance level of 0.05) revealed that the use of Crocodile ICT 605 software in teaching flowchart does not help the mathematics progress of students in the level of cognitive knowledge, but is effective in meta-knowledge level of students.

Keywords: Mathematics, flowchart, constructivism, algorithm, educational progress, Crocodile ICT 605 software, cognitive knowledge, meta-knowledge.

1 Introduction

In view of the progress of societies, education systems and the activities they pursue are subject to change and transformation. Educational transformation itself is caused by social transformation and scientific and technological achievements. Learning new sciences and skills requires advanced educational methods and teachers today have heavier and more complicated duties and responsibilities compared to the past. Traditional methods can no longer lead societies towards progress and advancement. Nowadays, students have to gain research skills and mathematical solutions and enhance their spirit of searching, so it is very important to use efficient teaching methods which can increase activity of students and make learning a dynamic, bidirectional process [3]. Mathematics education software provides learners with rich resources which give them the
opportunity to progress in mathematics and create a collaborative environment which enables learners and teachers to search and discuss different issues [1]. In traditional education systems, learner was a passive component who had to pursue a series of predetermined goals. In modern education systems, however, learner creates the new knowledge. The active role of learner in gaining experience of learning mathematics, which is the main feature of modern approaches, particularly constructivism, is among the necessities of the modern teaching-learning system because the advent of educational technologies has made it more possible to meet the various needs of learners. By designing education based on constructivism and by creating the opportunity of choice based on learner's need, it becomes possible for learner to participate actively in construction of mathematical knowledge, determination of the goal of mathematics, regulation of time and making necessary planning [12]. One of the learning theories which has a close relationship with application of computer in education and has attracted the attention of many specialists in education of sciences and has shown positive results in different studies is the theory of constructivism. The core of constructivism concerns the nature of mankind's knowledge, particularly scientific knowledge. Constructivists believe that knowledge is not a transferrable product and is produced by individuals. In recent years, the concept of constructivism has drawn the attention of education specialists. This concept provides a model of how learning takes place [15]. In addition, according to the goals of mathematics education, one of the main questions in secondary studies is "how does man solve his daily problems?" Considering this, students should learn basics of programming in order to gain a good understanding of the steps and strategies in solving questions. After learning the fundamentals of computer science, students are expected to improve in scientific, mental, practical and attitudinal terms. Scientific goals include familiarity with computer hardware and software, basics of programming and learning a programming language. Mental and practical goals include familiarity with the method of solving questions and preparing a computer program for solving the questions. And attitudinal objective is to understand the importance of application of computer and the use of algorithm in solving mathematical questions. Programming requires question solving skills and exclusive thinking. These skills are necessary for every student to become successful in high school and in higher levels. The subject of flowchart is the basis of all programming languages and therefore students need to have a good basic knowledge so that they can gain necessary skill for programming. Most of Iranian schools use traditional and non-dynamic teaching methods. The aim of this study is to take advantages of modern software in education, with an emphasis on teaching flowchart and constructivism, and to make students familiar with information and communication technology in order learn mathematical concepts.

2 Theory of Constructivism and Approach of Behavioral Goals

According to constructivism, there is no knowledge independent of the meaning attributed to experience constructed by learner or community of learners. Constructivists reject the existence of any knowledge independent of learner [14]. They believe that knowledge is gained through the use of disperse information as the base of knowledge and extraction of new knowledge from them. Learners interpret information by using their experiences and their interpretation is always individualistic. Students interpret educational materials, which teacher designs for learning, by using their experience and knowledge and extract special meanings based on their needs and interests. Constructivists suggest that instead of trying to visualize an external reality for learners, they should be helped to achieve a meaningful picture of the external world. Constructivism is a model developed to describe how learning takes place. According to this model:

- Students learn when they actively participate in the process of learning,
- Learning is the process of understanding. Knowledge is not transferrable and is gained through interpretation of findings,
- Interpretation of findings is always under influence of past knowledge, and
- Interpretation of findings is supported by educational methods which make students to discuss the opinions of each other [4].
Computer-aided education in terms of constructivism has been paid high attention in recent years. Constructivism has considerably penetrated into education of modern sciences. In constructivist approach, computer is used as a tool for collecting and organizing information and showing what learners have learnt. Prior to being an educational theory, constructivism is a theory of knowing and learning. It is an approach for describing how learners learn, how they solve questions and how they understand the surrounding world. It should also be noted that the excessive vicinity of cognitive categories causes that when a behavioral goal is provided to several teachers, there is always no agreement between them in terms of the category they determine for the intended goal. In other words, separation of these categories (except knowledge category) is a very specialized, difficult and time-consuming job. On the other hand, the manner in which goals are determined limits the possibility to design questions which need more complicated mental activity. Considering the problems concerning, Bloom behavioral goals extraction, particularly disagreement between teachers or experts when determining the levels of behavioral goals, one of the proposed solutions is to divide cognitive categories into two categories of "knowledge" and "meta-knowledge". The behavioral goals which only concern remembrance are placed in knowledge category and other behavioral goals from the level of understanding to creation – according to Fig 1, are placed in meta-knowledge category. Considering that Bloom behavioral goals extraction method is at present used in final examinations, it can be used in designing and investigation of examination questions. Moreover, in the new approach to compilation of textbooks, in which evaluation is part of teaching-learning process, educational goals have been divided into three categories of scientific, skill and attitudinal goals [7].

Beyond Knowledge

(Comprehension, application, analysis, evaluation, creativity)

Knowledge

Figure 1: Behavior goals levels

3 Learning Based on Algorithm and Flowchart

Flowchart is in fact a drawing that software developers design before writing a program into the main programming language. By a review of flowchart, the process of executing operation, steps and details of program and input and output of each step of program is specified. Flowchart helps us solve questions and makes it easier to write a program irrespective of programming language. Moreover, flowchart is a valuable part of documentation of any program which facilitates interpretation of program, troubleshooting, and use by a person other than software developer. In order to design flowchart, it is necessary to have a good command of the required steps so as to achieve the desired results by using the data inputted to the algorithm for which flowchart is designed. Flowchart is a tool for logical design of computer programs which is the main nature of a program. Nowadays, in view of the ever-increasing use of programming and the necessity of teaching it, the role of flowchart as a tool for developing program is becoming more and more important. This is more obvious owing to graphical shape of flowchart and clarity of the order of its different steps. Furthermore, the level of flowchart may be considered to be higher than all programming languages because its commands are very close to natural language and understanding the function of graphical blocks is easier than program codes. Owing to these advantages, flowchart continues to be used both as an educational tool and as a high level language for showing algorithms [4]. Programming process has six steps as follows [13]: First step- Definition of problem: the first duty of a programmer is to exactly define the question. In this step, he should determine the objective of question, desired output, required input and an appropriate processing. Second step- Designing the method of solving the problem: having defined the question, programmer should specify how
exactly the question is to be solved. In this step, he has to design a step-by-step process from the required input to the desired output. The combination of necessary steps in the process of achieving the desired output out of the required input is named algorithm. In order to prepare an algorithm, programmer should clearly define the method of solving the question by using sentences and diagrams. There are many ways to do this, including pseudo code and flow diagram [13]. Third step – Coding the method of solving: in this step algorithm is presented by using a programming language. Fourth step – Testing program: The program is executed in computer in order to find probable problems and eliminate them. In this step a table of different inputted data (both valid and non-valid) should be prepared and possible mistakes should be found after executing the program. Fifth step – Documentation: writing all steps of programming in order to make it easier to use and generalize the program. Sixth step – Extension and maintenance: In this step, the problems discovered when using the program are removed and the program is promoted and optimized so as to adapt to new hardware and software. Each algorithm may have several end points but should have only one start point. There are three important factors in providing a solution:

- **Definition of question:**
  - A) Data
  - B) Unknowns
  - C) Relationship between data and unknowns

- **Designing the method of solving the question:** after definition of the question, we should provide a solution for it.

![Figure 2: Six steps of programming process](image)

### 4 Review of Literature

Many studies have been made about teaching and learning mathematics by means of information technology, some of which are mentioned below: Hosseini (2009) concluded in his research that there are many factors in movement of education towards ICT based curriculum, which are: rapid growth of science and technology, increase of specialized majors in each field of study, the excessive distance between the needs of the society and what the present education system provides, failure of the present education system to meet various needs of the society, the increased level of skill and knowledge needed to perform activities in a specialized field, the use of technology for exploratory and reflective learning, the effect of mathematics in the progress of computer science, and the effect of computer in the progress of mathematics. He revealed that ICT can improve three aspects of teaching and learning mathematics: 1) pedagogy, 2) mathematics, and 3) organization [8]. Filsell & Barnes (2008) made a research on the use of new technologies in teaching-learning process in the ministry of education and employment of Australia, and place special emphasis on learning technologies such as educational games, simulation and multimedia [11]. Mafi (2011) revealed in his research that the use of computer software and production of electronic content has positive effect on teaching mathematics and student's attitude and learning. Statistical analysis revealed that mathematics teachers of secondary school are not sufficiently familiar with computer software and do not have the ability to teach mathematics by help of computer, but they are interested and believed in electronic education of mathematics. The mathematics teachers involved in this research believed that the time allocated to mathematics in weekly program of students is not sufficient for electronic education [6].
5 Research Hypothesis

First hypothesis: The use of Crocodile ICT 605 software in teaching flowchart helps students to progress in mathematics in the level of "cognitive knowledge".
Second hypothesis: The use of Crocodile ICT 605 software in teaching flowchart helps students to progress in mathematics in the level of "meta-knowledge".

6 Research Methodology

The present study is an applied research. Since the population under study is human and it was not possible to fully control the variables, quasi-experimental method was used. The group under study was divided into two groups: experiment group and control group. Experiment group consists of students who have learned algorithm by using Crocodile ICT 605. Control group consists of students who have performed educational cases by designing operational schemes traditionally on paper.

7 Participants

Statistical population of this research consists of girl students of the third year of high school in the field of mathematics from state high schools in the city of Tehran in school year 2012-2013. Sampling was performed by multi-step cluster method. Two high schools were randomly selected from among girls' high schools of Tehran. Both high schools included four mathematics classes for students of the third year. In each school, two out of the four classes were randomly selected, one as control group and the other as experiment group. Control group consisted of 30 students and experiment group consisted of 25 students.

8 Research Tools

One of the tools used in this research is Crocodile ICT 605. Crocodile is a series of software programs in the fields of physics, chemistry, mathematics, technology, etc., which provide user with a simulated environment. Crocodile ICT 605 enables user to investigate the authenticity of flowchart of the designed algorithm step by step. Crocodile ICT 605 flowchart software enables users to use flowchart. The only thing that students have to do is to bring symbols to edition area and connect these symbols to each other. In such cases, students can concentrate on the authenticity of algorithms. Moreover, students can test their operational schemes and investigate their authenticity. In other words, by help of Crocodile ICT 605 software, student can easily learn programming aspects and perform it by designing operational schemes. Furthermore, there is no grammar error and this enables students to concentrate on algorithms. They are also able to stop the work in any step during test and then recover it. This software has been designed based on the main components of constructivism. When a Crocodile ICT 605 file is opened, a new operational scheme with internal symbols is formed. User can use one of the symbols of operational scheme and the related structure for the following cases:

- Input symbols
- Output symbols
- Choosing structures
- Structural circles

This educational software includes three parts: contents, library and properties. Contents part consists of 16 subsections which constitute about 30 parts of teaching flowchart and include such cases as structures, different approaches and tests. Library part has three subsections each including special symbols. By activating each symbol, the relevant properties are specified (e.g. testing algorithms). In effect, Crocodile ICT
605 covers most of the subjects presented in this model. An example of class activities will be presented later. Design an algorithm to calculate and print the total of $S = 1 + 2 + 3 + \ldots + N$.

<table>
<thead>
<tr>
<th>N</th>
<th>I</th>
<th>S</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1</td>
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<tr>
<td>3</td>
<td>3</td>
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<tr>
<td>5</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>15</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3: Sum algorithm $S = 1 + 2 + 3 + \ldots + N$

Figure 4: Sum algorithm $S = 1 + 2 + 3 + \ldots + N$ in Crocodile ICT 605
Furthermore, mathematics scores of the previous year were used to compare mathematics status of experiment and control groups before executing the teacher-made test. The third research tool is teacher-made test. To make a valid test, a table of goal-content specifications was first prepared after investigating the content and literature and interviewing with scholars. Next, after classifying and summarizing the achieved content, some questions were prepared from the subjects which had been taught during the research, considering the levels of "knowledge" and "meta-knowledge" of the intended subject, in order to assess educational progress of students. Then some open-ended questions were provided to a number of students in order to ensure they understand the content. After that, class tests were prepared. Finally, validity and reliability of the teacher-made test was confirmed (≥ 0.7).

9 Data Collecting Method

To carry out the research, algorithm laboratory software was collected by the researcher from internet sites. Then, from among the collected software, the software suitable to the contents of the book "fundamentals of computer sciences" from the third year of secondary school was selected. Investigation of mathematics scores revealed that there is no significant difference between experiment and control groups in "knowledge" level. Teaching method was that control group performed the educational cases traditionally in classroom by designing operational schemes on paper. Experiment group did the same by help of computer and Crocodile ICT 605 software in computer site. The two groups performed the educational cases for a period of six weeks. At the end of the period, both groups were given some questions to answer.

10 Findings

To investigate the two hypotheses, mean and standard deviation were first investigated in the section of descriptive statistics. As we can see in Table 1, the mean scores of experiment and control groups are equal in cognitive knowledge level. Also, standard deviation of the scores of experiment and control groups is 0.51 and 0.65 respectively. This means that distribution of the scores is almost similar. Also, the mean scores of experiment and control groups in meta-knowledge level are 12.94 and 10.4 respectively, which are different by 2.54. This difference can well indicate the superiority of experiment group over control group. Also, standard deviation of the scores is 2.31 and 2.43 respectively, which means that distribution of scores of the two groups is almost similar.

<table>
<thead>
<tr>
<th>Posttests</th>
<th>N</th>
<th>Mean</th>
<th>STD</th>
<th>Variance</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment Group</td>
<td>25</td>
<td>4.46</td>
<td>51.0</td>
<td>0.26</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Control Group</td>
<td>30</td>
<td>4.46</td>
<td>65.0</td>
<td>0.43</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 1: Descriptive statistics for cognitive and meta-knowledge learning

The normality of the scores obtained by experiment and control groups was assessed by Kolmogorov-Smirnov test. P-values were 0.21 and 0.01 respectively. Distribution of experiment group data was normal but that of control group data was not normal (P<0.05), so we cannot accept the hypothesis that all data of cognitive test is normal. Therefore, we used Mann Whitney test to examine equality of means.
According to Table 2, P-value is P>0.05. Therefore, the hypothesis of equality is accepted. This means that both groups have equal mean scores in cognitive knowledge test. According to investigation, therefore, the first hypothesis of the research was rejected. In other words, the use of Crocodile ICT 605 software does not help students to progress in mathematics in cognitive knowledge level. To investigate the second assumption, after having ensured the normality of data by Kolmogorov-Smirnov test (P>0.05) and having investigated the equality of pretests, we investigate the posttests of control and experiment groups in meta-knowledge level. For this purpose we use T-test in significance level of 0.05.

As you see in Table 3, P-value is more than 0.05, so the equality of variances of the two groups was confirmed. Now we follow the route of equal variances in the Table. Since in T-test in this route, P-value is less than 0.05, the hypothesis of equality is not accepted. This means that mean scores of meta-knowledge posttest of the two groups is not equal. Since the mean of experiment group is bigger than that of control group, we conclude that the use of Crocodile ICT 605 software in teaching flowchart helps students progress in mathematics in meta-knowledge level.

11 Discussion

Data analysis revealed that the use of Crocodile ICT 605 software in teaching flowchart does not improve the learning quality of students in the level of cognitive level but improves their learning quality in meta-knowledge level. Among the reason why the first hypothesis is rejected we can mention the applicability of the software. The findings of this part of the research correspond to the studies made by Dal & Trish (2001) who provided students with open-goal activities and experiences giving them the opportunity to remake the concepts and gain a very complicated and deep understanding [2,3]. The second hypothesis was confirmed, so we can conclude that the use of Crocodile ICT 605 software helps students progress in mathematics in meta-knowledge level. In other words, teaching flowchart by help of Crocodile ICT 605 based on constructivism theory has generally improved the educational progress of students. The findings of this part of the research correspond to the studies made by Saadatmand (2002) who revealed that new technologies such as computer and multimedia improve the process of teaching-learning. Students' interest in working with software can speed up learning process [10]. Since learner's motivation is the central part of the learning process, simulation and use of software not only increases the curiosity of students but also helps them progress in their lessons. According to the theory of constructivism, the goal of teaching and learning algorithm is to grow and develop reasoning and to use mathematics in actual situations of life. A constructivist student himself is responsible for

<table>
<thead>
<tr>
<th>Posttests for experiment and control groups</th>
<th>Sig</th>
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<tbody>
<tr>
<td></td>
<td>0.66</td>
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<table>
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<tr>
<th>Posttests</th>
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<th>t-test for Equality of Means</th>
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<tbody>
<tr>
<td></td>
<td>F</td>
<td>sig</td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>0.06</td>
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</tr>
<tr>
<td>Equal Variances not assumed</td>
<td>3.96</td>
<td>52.05</td>
</tr>
</tbody>
</table>

Table 2: The results of Mann-Whitney for cognitive knowledge level

Table 3: The results of T-test for meta-knowledge level
learning. Modern technologies can enhance the curiosity and creativity of students helping them learn new lessons. When using software environments, students can change and modify pictures and thereby can observe some features better. This is the main advantage of software environment over traditional education in teaching and learning processes. According to constructivism, students discover mathematics lessons by doing activities in software environment. The software environment of Crocodile ICT 605 provides enough freedom and flexibility which give student the opportunity to test and discover things and develop mathematical concepts, which is very important in constructivism.

12 Conclusion

Constructivism is a useful and valuable theory, because it delineates what happens in mathematics class better and more clearly. This theory considers teacher as a factor which facilitates the learning process and makes students learn things and solve questions by providing appropriate work space. By forming small workgroups, he gives students the opportunity to express their mental images of the concepts and offer their solutions. This is a progressive and developmental process which can encourage students with any level of ability to learn mathematics. The philosophy of constructivism concentrates on what students can do to combine the new knowledge with the existing knowledge so as to gain a deep understanding of mathematics. This philosophy considers students as active participants in the process of teaching and learning. In mathematical activities, apart from certain subjects such as geometry which have a series of realistic capabilities, in most of the cases we have to bring the pure reality to classroom and simulate it for learners so that they feel the pure reality. ICT has made this possible in teaching mathematics. With respect to solving questions, the most popular sample is "dynamic sample" in which student should be able to understand the question. Therefore it is recommended that mathematics teachers provide an appropriate environment in classroom so that students can express their viewpoints concerning a subject or question. They should encourage students to use mathematics in real situations. Moreover, in line with using constructivism-based teaching method, the ministry of education should provide teachers with short-term and long-term courses so that they get familiar with the use of modern teaching methods and educational software. The ministry should also publish journals about new educational software to make teachers familiar with the most recent products in this field. At the end, we should say that constructivism approach is found to be more efficient than traditional method which has been developed in 1890s. This method can help and encourage learners to make a relationship between their activities and the rich cultural heritage of mathematics.

References


