Research Journal of Applied Sciences, Engineering and Technology 7(21): 4455-4463, 2014
DOI:10.19026/rjaset.7.822
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: December 09, 2013 Accepted: January 29, 2014 Published: June 05, 2014

Research Article

Learning Programming through Multimedia and Dry-run

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Abstract: The purpose of this study is to evaluate the learning effectiveness, learners' satisfaction and behavioral intention using multimedia and dry-run based instruction for learning abstract concepts of computer programming. This study has been conducted on computer science students of degree class on Degree College's curriculum of programming, as compared to a similar sample size of degree class having same curriculum of another Degree College, including identical learning goals and content but missing the Multimedia and dry-run based instruction. In this study, questionnaires used for analysis of multimedia and dry-run based instructions. The impact of multimedia and dry-run is also investigated on assessment scores of learners. It is investigated and concluded, that which method is better for instruction of computer programming for students.

Keywords: Dry-run, multimedia, play role, programming

INTRODUCTION

Various new teaching-learning methods are discovered in the last few decades like multisensory/technology (Dede *et al*., 1999) based learning and blended/blended learning (Mead *et al*., 2006). These modern learning methods are widely used for technologically enhanced learning. Recently, new discoveries in cognitive sciences/psychology, brain research as well as accelerated integration of technology such as computer, multimedia, projector, social network, internet and intranet with other traditional learning methods bring rapid advancements in such type of learning processes in education. These modern techniques can provide solutions to the new changing learning environment; these techniques are flexible enough to cope with variety of backgrounds and qualifications. The more difficulties are faced in finding ways to apply the new methods and technologies to the learning process with recognized educational benefits. Modern e-learning has enhanced the conventional classroom practice in through substantial way of Multi-Sensory Learning (MSL) objects. Over the past few years, we have come to realize that different students learn in diverse ways. Therefore, teachers should present students with multiple teaching mediums in a structured learning environment. These mediums should integrate visual, auditory and kinesthetic sensory inputs to improve content absorption. Each learner then uses one of these inputs as their primary method of learning while the additional inputs are used as reinforcement. Proper tools are required to overcome the time, space and performance demands, which are due to the geographical distribution of education and training centers. Such tools and techniques can be developed by the utilization of multimedia systems for education and other technique of education and training such as dry-runs (step by step execution), play role and practical. There are some basic teaching-learning strategies.

Conventional: In this strategy, teachers communicate knowledge to the students through face to face teaching method. The role of teacher is like an instructor, decision maker or controller who teaches the students and students sit in the class room to watch and listen.

Multisensory: In this strategy, the learners are facilitated to learn through more than one senses such as sight/visual (it is used in reading information from book, board or multimedia slides), hearing/auditory (it is used to listen the teacher's lecture) or touch/tactile and movement/kinetic (it is used to understand practically) (Dede *et al*., 1999). The involvement of more than one child's senses, help the child's brain to pick some knowledge from one sense and some from another sense.

Blended/hybrid: Blended learning is an affective combination of various delivery modes, teaching models and styles of learning. It is the amalgamation of face to face teaching method and e-learning approach. This method is pretty useful for improvement content absorption by students.

In traditional face to face learning students may easily adopt inactive role throughout the lesson, because they depend on teacher. That is why most of the students become passive in classes and not being

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able to embrace ample knowledge (Singh and Reed, 2001). In this study, we have investigated and analyzed, that how could we integrate the educationally valuable outcomes of these trends and computer-programming education. We have also investigated, that how and in what ways this process could be catalyzed by dry-run and play role. We presented a literature review based on simulation, dry run and play role based multi-sensory teaching-learning strategies in computer science education as this study focuses on these methods of teaching and learning.

LITERATURE REVIEW

The addition of technology in education has exposed new vistas for teachers and researcher who are more involved in multisensory learning approaches. The multisensory method is almost 90 years old and currently this movement is entered into new era. The advent of digital elements moved multisensory learning closer modern educational approaches similar to blended and blended learning. The blended learning method combines the traditional face to face instructions with different online technologies (Swenson and Evans, 2003).

Blended courses if carefully designed, integrate the finest features of traditional face to face teaching with the best features of e-learning (Riffell and Sibley, 2005). Students who are provided science education with real world examples through simulations and videos produced better results as compared to those students who only experienced traditional instruction methods (Fjermestad *et al*., 2005). Blended learning is a learning phenomenon where multiple delivery modes are being used to maximize the learning outcome (Singh and Reed, 2001). Blended learning is the real amalgamation of various methods of delivery, representations of teaching and learning styles (Berg and Knop, 2008). The research shows that optimal blended/blended learning approaches are based on the principles of multi-sensory learning. The multisensory learning is very effective in designing blended courses and it contributes to the effective integration of optimal mixture of various methods of blended learning. The benefits of multi-sensory learning for young students and for students suffering from learning disabilities have been revealed by years of research efforts. Unfortunately its effectiveness at higher grades has been ignored for so long.

The success of multisensory learning at all levels can be justified by making mathematics real curriculum which shows that how much multisensory method can enhance the teaching and learning process (Berg and Knop, 2008). In human brain constant multisensory stimulation is caused by daily life activities and natural environment. The authors in Shams and Seitz (2008) has shown that human brain effectively learns and optimally operates in such environments where information is integrated across multisensory models, that is why multisensory learning methods produce better results. Digital elements have moved multi-sensory learning closer to other modern educational concepts like blended and blended learning.

Blended education combines traditional face-to-face instruction with online technologies. Teaching approaches are changed by multimedia learning tools at all levels in educational institutes. New applications are added in curriculum of all the fields of education. The abstract concepts are represented through realistic animations, attractive colors and musical sounds to make easy to understand. Software tools are developed to increase its impact of multimedia in education, in Wong *et al*. (2005) software tool called user-in-the-loop feature is represented. Computer games and other multimedia applications can be very effective in motivating students to learn and to better understand the studied topics (Philpot, 2005). These games are very effective to foster the proficiency and confidence level in narrowly defined but critical topics through the use of repetition and carefully created levels of difficulty. The experimental outcomes of numerous articles in virtual reality also stipulate that abstract notions into mutually supporting multi-sensory representations enhance students' understanding of scientific models (Hall *et al*., 1997).

Multimedia educational techniques work in same manner as perceptual research of multi-sensory assistance. The dual-coding theory indicates that large size total information can be handled easily once information enters into the system via several processing channels (Clark and Paivio, 1991).

Most of the research in scientific education revealed that it is difficult to understand complex scientific information, because most of the scientific domains mostly deal with non-concrete concepts which are difficult for students to understand. The scientific models (Concepts, Mathematical Models) are based on phenomena which have no real-life examples or reference and integrate invisible factors and ideas (Dede *et al*., 1999). Particularly in computer programming which is based on several abstract process learning is challenging (Katai *et al*., 2008).

In Mead *et al*. (2006), authors have identified the problems faced by students in learning programming. Most of the students are facing problems in converting algorithm structures into programs (Spohrer and Soloway, 1986; Soloway *et al*., 1983; Winslow, 1996). They have also pointed out the problems that were commonly faced by students and the students cannot develop, design and trace program at acceptable level. Meanwhile algorithms that incorporate loops and recursive sub-programs are categorized by high-level abstractness. During this study our main focus is on the programming education because very high percentage of the science and engineering students confronting difficulties in learning programs during the first semester of their computer programming course. This area requires so much concentration in order to make

the programming education more effective and easy to learn.

In Rasala *et al*. (1994), authors have compared traditional algorithm teaching with the blended methods of teaching which integrate animations and data analysis. Their results regarding the three software applications which are incorporated in computer programming syllabus also shows the competence of multimedia methods in the field of computer science. They have performed the analysis of the sorting algorithms allowed each algorithm to be treated in exactly the same manner: Firstly run the algorithm and then store the record of its performance. These algorithm animations provide students with comprehensive perception of how the algorithm works. This has improved their gut level feeling for various algorithms.

In Katai *et al*. (2008), they have represented the notion of loop skeleton. They have introduced a software-tool which is based on multi-sensory approach. This tool automatically creates program skeletons containing different loop structures by only giving the loop skeleton parameters. This software integrates piano sound and delay events in the middle of each loop. It plays the role of a loudspeaker to the loop skeletons. When the algorithm containing loops in both the corresponding branches of a selection, in these matching loops they have implemented the similar sounds but with some variation in musical instruments. This tool has utilized the multisensory learning approach, in which students listen the sequence of piano sounds which characterizes the loop skeleton of algorithm. The students focus their eyes on the running of program which is going to be executed. The method is very effective for learning algorithms and students can learn algorithm even if computers are not available.

The recursive-procedure-skeleton is introduced in (Katai, 2009). This approach is helpful in understanding that how recursion works. In this approach students are asked to play the running process of diverse recursive functions. The students are allocated different roles like one of the students is assigned the role of main function while the other students play the role of instances of the function. Local variables and formal parameters are denoted by the pieces of paper in the hands of different students. While the other students act as spectators who view the whole process to understand recursive functions. The results were very fruitful and this multisensory method was very effective in improving the skill of students in algorithm analysis and designing.

In Dalacosta *et al*. (2009), the authors stress on the usage of animated cartoons in various multimedia applications intended to assess their efficacy in teaching and learning in engineering and other fields of science. They have developed multimedia application based on cartoon style; these cartoons were designed from scratch using programs. This study has been carried out in different elementary schools of Greece. The results testified that the usage of cartoons and multimedia enhanced the young students' knowledge and their capability of understanding different scientific concepts, which are not easy to understand in traditional teaching-learning environment. The cartoon representation provided significant advantages as learning in multimedia applications especially for scientific knowledge in a popular that is enjoyed by younger students.

In Ahmad *et al*. (2010), they have presented a case study comprising students in three different courses on Diploma Program in Multimedia University who are learning Business mathematics as a subject. They have arbitrarily nominated groups of students were assigned different types of teaching methods; one is by using multimedia while the other method was without using multimedia. The results of this study exposed that students who were taught with the help of multimedia aid scored higher as compared to those students who were only relying on the traditional teaching-learning method. This indicates that teaching students using pictorial representation, step by step execution, sounds, games and simulation would inspire the students in quick understanding of scientific concepts as compared to traditional face to face method. It may be due to the different aspects such as the multimedia approach is based on visual presentation, sounds and 3D shapes; simulation is based on real world representation; dry-run is based on the step by step execution and flow of the event that the event has to be occur in reality, which are more helpful and interesting to remember.

RESEARCH METHODOLOGY

In this research, the adopted method has been focused on collecting data to find out the impact of multi-sensory/technology based learning for understanding abstract concepts of introductory computer programming course for undergraduate students, their self-efficacy and satisfaction. This also helps to investigate the answer of the research questions that, which method is better? More specifically, the qualitative and quantitative approaches were used in this research for analyzing the effects of adopted methods.

Participants: The participants of this research study were the students of two Government Girls Degree Colleges (GGDC), Abbottabad, Pakistan. This study conducts qualitative analysis and quantitative analysis. All the participants/students of second year class of high school and third year class of B.Sc of both colleges have got admission on merit criteria of the colleges. The distribution of research materials, questionnaires and analysis were conducted by the authors, who were independent of the course content

and assessment scores of the students (as Abbottabad board for high school and Hazara University for bachelor conduct the exams and give assessment scores).

The totals of 42 students were taken for the study in the following two groups:

- **Control group:** Contains 21 students of GGDC No. 2 and conventional method was adopted for them. For this group computer was used only for conducting the practical work related to course contents.
- **Experimental group:** Contains 21 students of GGDC No. 1 and presented with the multi sensory methods of instruction i.e., multimedia and dry-run adopted with the conventional method and computer practical.

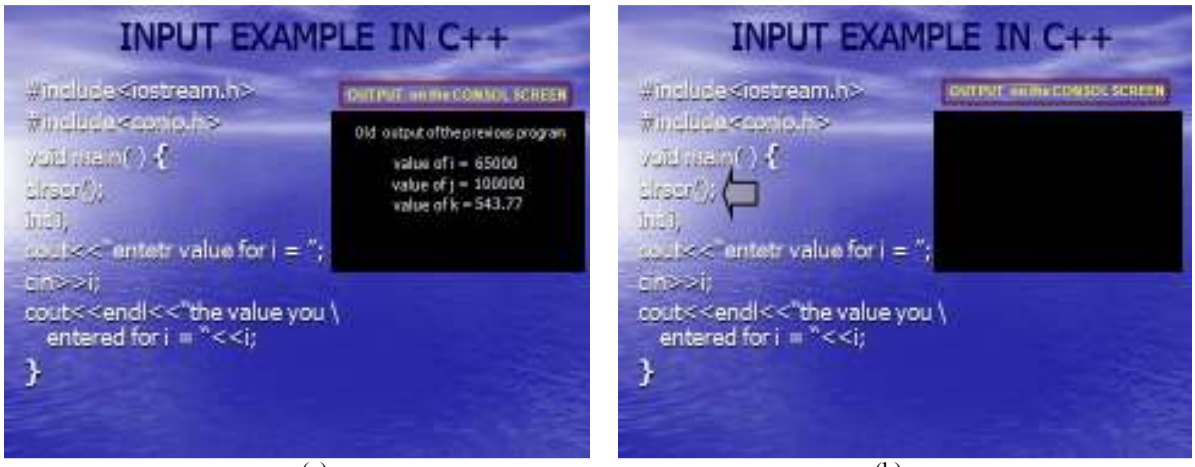
For qualitative analysis, a survey was conducted to understand learner's attitude towards multimedia and dry-run based instructions. After using the proposed methods, students from experimental group were given two questionnaires; First a learner's satisfaction and behavioral intention survey inventory originally designed by Liaw (2008), which has been modified and took in this survey. Second a demographic information survey designed by authors. The participants were asked to complete the questionnaire to know the experience and attitudes toward multimedia and dry-run based instruction.

For quantitative analysis, we have taken pre-test based on the practical marks from result cards of second year (F.Sc) issued by BISE Abbottabad and then for post-test based on the practical marks from result cards of third year (B.Sc) issued by Hazara University on both control and experimental groups.

Instructional material: In this research, we have investigated the impact of different learning environments on satisfaction and learning achievement score of students. We have used conventional instruction method in one college with practical use of computer system, these are control group learners. In this method, the instructor delivers computer lectures on white board and students practice the programs on the computer system. On the other hand we have applied the multimedia and dry-run based methods of instruction for the same contents in another college, these are experimental group learners. The proposed method was conducted with the combination of conventional method and computer system. The main differences of course contents of second year and third year classes are these: the former class has abstract concept of declaration and initialization of variables, control statements and loops in the C language editor and the later class contains some advance abstract concept of structures, pointers and link list, arrays and sorting with the basic programming contents but in C++ language editor. The following subsections describe some examples of learning of some basic contents of computer programming.

Teaching-learning elementary algorithms using multimedia: Multimedia is one of the technology-based medium for effective delivery of instructions. In this section, we describe learning through multimedia instructions, which have promoted computer programming education, especially for beginners in our experiment. We have focused on the utmost abstract points of the programming teaching-learning process. The line by line execution of basic concept of entering data through keyboard is illustrated in Fig. 1.

Teaching-learning sorting algorithms using dry-run: In Robins *et al*. (2003), discussed that most of the students in a first programming course make very limited understanding and progress. For experimental group we presented dry-run approach, in which pen



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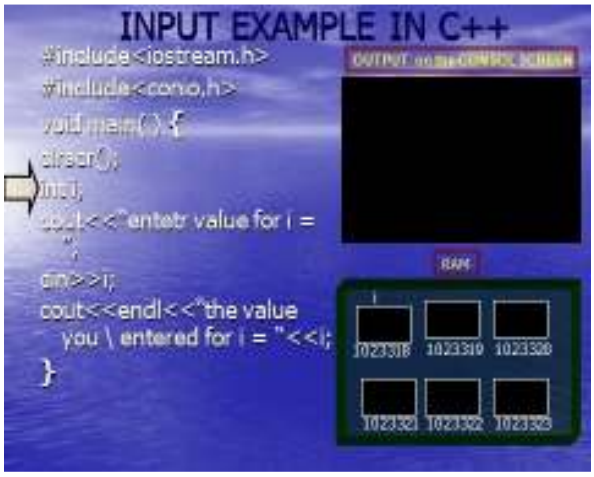

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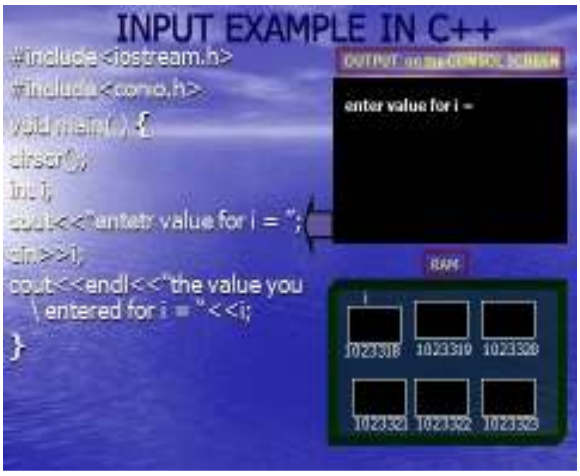

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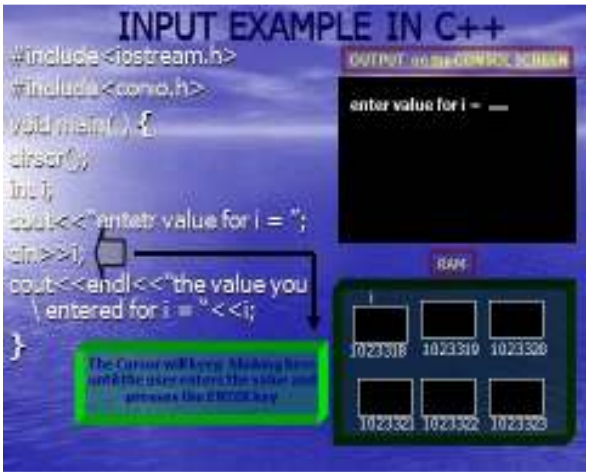

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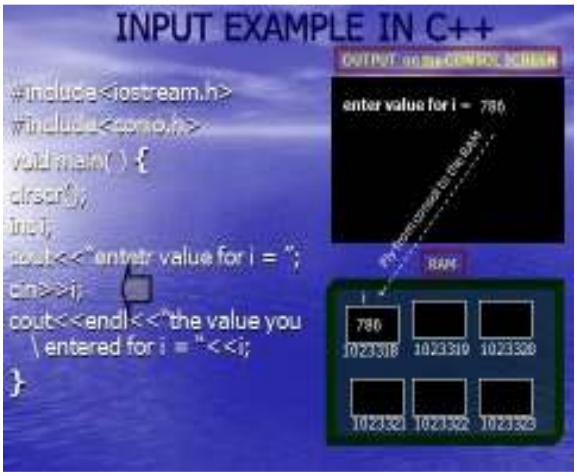

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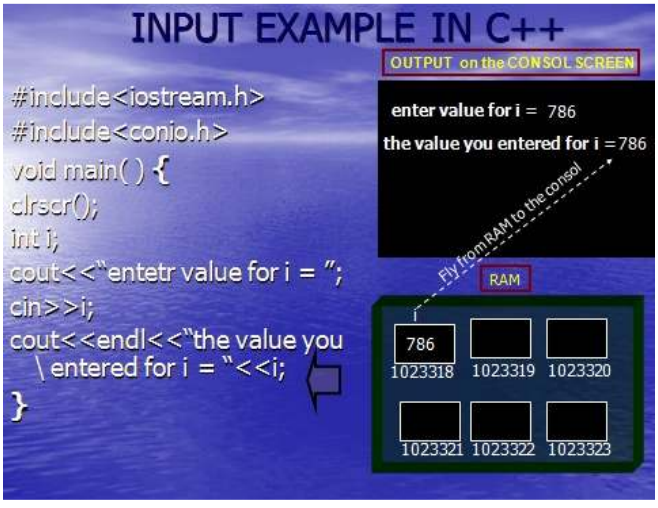

(g)

Fig. 1: Programe of input example in C++, (a) output of previous program will clear with clrscr() command, (b) initialization of variable i, (c) displaying a massage, (d) enter value from keyboard, (d) cursor blinks after execution of cin command, (f) internal logic of storing value in a variable from console screen, (g) display the message and variable's value

and paper method is used for line by line execution of the computer program for understanding the main concepts of sorting algorithms in the beginner's class of C++. We called the line by line execution as dry-run in this study. Dry-run allows running of sorting algorithms line by line in a visual way on a paper that learners have to know the execution of each line, to learn the logic and flow of program in the RAM. ALU, registers and processor and interfacing. Dry-run enables learners to think in advance by writing the flow of control of the program in words; what you want to program that help in making decision for designing logic.

The line by line execution method is a source of visually presenting the flow of data by means of an information processing systems, the operations performed inside the system and the sequence in which they are performed. The dry-run approach forces the learners to pay particular attention to the line by line and word by word execution of program. The programmer prefers to write step-by-step execution prior to writing a computer program and the step-by-step execution of programs helps students learn to analyze programs.

The problem-solving tasks in sorting algorithms addressed by our students include:

- Evaluating expressions of sorting algorithms step-by-step
- Predicting the output of a program line by line
- Analyze the dry-run of a program for identifying bugs in a program and which line code has what output

The primary focus of the anthers is to understand the internal flow and logic of programming and to write program in proper way and student become able to tackle with errors.

Assessment instruments: The three data sets have been gathered in this research, that are information about learner's satisfaction, behavioral intention and effectiveness (ordinal data) of exploited learning environments; assessment score (interval data) of the learners and demographic information (nominal data) of learners of experimental group to know the effect of their past experiences and surrounding on the learners. Following instruments are used to collect the mentioned data sets.

Learners satisfaction and behavioral intention towards future use: These questionnaires were designed in Liaw (2008) and modified and then used in our research study, to investigate learner's satisfaction, behavioral intention and effectiveness of multimedia experience and attitude toward dry-run. In these data sets, data has been collected from participants/learners to know whether they had experienced using the multimedia based instructions and the participants were also assessed to know their attitudes toward dry-nun based instruction. These two questionnaires, each containing 21 questions were answered using all 5-point Liker scale (ranging from 1 which means ''Strongly Disagree'' to 5 which means ''Strongly Agree''). The median has been calculated to know a learner's response for all 21 questions.

Assessment score data set: This included the assessment scores of learners that were used to find the improvement difference between post-test and pre-test score. In this research, we may discuss assessment score of 2nd year for pre-test and assessment score of 3rd year for post test and then find out means and independent t-test for determining the difference.

Demographic information: The demographic data set covered age, first time use of computer, Internet, their interest in free times, Computer supported education and the study field of family members. This might be used in participant screening.

RESULTS AND DISCUSSION

In this study, we have performed two types of data analysis, to analyze the learner satisfaction and behavioral intention using multimedia and dry-run and to know the impact of multimedia and dry-run instruction on the student's assessment score. To find out the answer for the research question we performed the two types of data analysis i.e., qualitative analysis and quantitative analysis.

Non-parametric results: Learners have been observed during multimedia instruction and during the interventions when they were doing dry-runs. After completion of curriculum using multimedia and dry-run interventions, learner's views on the multimedia and dry-run instruction have been taken through a feedback questionnaire as shown in Table 1 and 2. Data analyses showed that these approaches are more effective in promoting students' knowledge about the editor environment and console screen of C++ language and system processor, ALU and computer memory (RAM) concepts. Also this approach was found to be helpful for the students in understanding the abstract concept of computer programming. According to non-parametric results, it is concluded, that multi-sensory approaches for instruction are more motivational as compared to the traditional approach.

Parametric results: We have conducted "independent t-test" for analyzing the pretest and post test scores on the control and experimental groups. For both groups, the assessment scores of second year were taken as the pre-test before implementation of the proposed

Table 1: Median of multimedia based instruction

Items	Median
Perceived self-efficacy:	5
I feel confident using the multimedia	5
I feel confident learning through multimedia	5
I feel confident watching the slide show	5
Perceived satisfaction:	5
I am satisfied with multimedia based instructions	5
I am satisfied with learning contents	5
I am satisfied with multimedia instruction	5
Perceived usefulness:	5
I believe multimedia contents are informative	5
I believe multimedia is a useful instructions delivery method	5
I believe multimedia contents are useful	5
Behavioral intention:	5
I intend to use multimedia based instructions to assist my learning	5
I intend to use multimedia content to assist my learning	5
I intend to use multimedia as instructions delivery method	5
Interactive learning activities:	5
I would like to share my multimedia experience	5
I believe multimedia can assist teacher-learner interaction	5
I believe multimedia can assist learner-learner interaction	5
Multimedia effectiveness:	5
I believe multimedia can assist learning efficiency	4
I believe multimedia can assist learning performance	5
I believe multimedia can assist learning motivation	5
Multimedia instruction:	5
I like to use pictorial instructions	5
I like to use animated instructions	5
I like to use multimedia instruction	5

Table 2: Median of dry-run based instruction

Items	Median
Perceived self-efficacy:	5
I feel confident doing the dry run on paper	4
I feel confident learning through dry run	5
I feel confident writing the flow of programs on paper	5
Perceived satisfaction:	5
I am satisfied with using dry run as a learning assisted	5
I am satisfied with using dry run for learning logic of program	5
I am satisfied with dry run based instruction	5
Perceived usefulness:	5
I believe dry run based contents are informative	5
I believe dry run is a useful learning method	5
I believe dry run method is useful	5
Behavioral intention:	4
I intend to use dry run to assist my learning	4
I intend to use dry run method to assist my learning	4
I intend to use dry run as an autonomous learning method	5
Interactive learning activities:	5
I would like to share my dry run experience	5
I believe dry run can assist teacher-learner interaction	5
I believe dry run can assist learner-learner interaction	5
Dry run effectiveness:	5
I believe dry run can assist learning efficiency	5
I believe dry run can assist learning performance	5
I believe dry run can assist learning motivation	5
Dry run instruction:	5
I like to use dry run to understand flow of a program visually	5
I like to use dry run for understanding for logic programs	5
I like to use dry run instruction	5

instructional methods and the third year assessment scores were taken as the post test after applying the multimedia and dry-run instructional methods shown in Fig. 2.

The difference has investigated in learning gain between conventional and multimedia and dry-run based learning. It was expected that learners of experimental group would get promising score as compare to learners in controlled group; because multimedia based instruction provides pictorial information and dry run based instruction depicts the internal flow and logic of programming the learners, which is very helpful in understanding the abstract concept of programming.

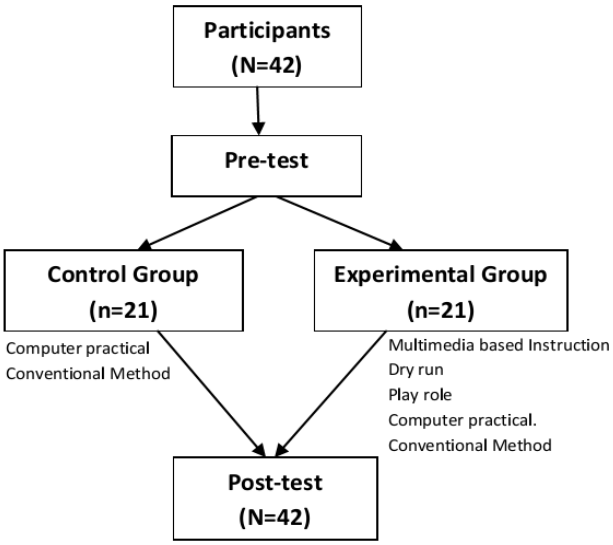

Fig. 2: Quantitative analysis flow

Table 3: Pre test: mean of 2nd year's assessment scores using conventional methods-control group vs. experimental group

	Groups	N	Mean	Equality of variance		t-test for equality of means	
Pre test	Control group	21	20.50	F	p-value	t	p-value (2-tailed)
	Experimental group	21	21.16	0.204	0.655	-0.442	0.662

Table 4: Post test: mean of 3rd year's assessment scores using multimedia and dry-run based instruction-control group vs. experimental group

	Groups	N	Mean	Equality of variance		t-test for equality of means	
Post test	Control group	21	15.24	F	p-value	t	p-value (2-tailed)
	Experimental group	21	20.24	8.571	0.006	-4.932	0.000

Using an independent t-test, the means of controlled and experimental groups are compared as a pre-test and post-test and the results have shown in Table 3 and 4.

The results of pre-test showed that there is not considerable difference between experimental and controlled groups. The mean score of experimental groups is M = 21.16 with S = 3.042 and mean score of controlled group is M = 20.50 with S = 3.619. The results of post test showed that the mean score of experimental groups (M = 20.24, S = 2.278) is higher than mean score of controlled group (M = 15.24, S = 4.049). It is concluded from the analysis that there is statistical significant difference p = 0.006 (at the $p<0.05$) between the assessment scores of controlled and experimental groups after learning trough the multimedia and dry-run. The results show that the learners got higher learning performance when the multimedia and dry-run based instructional methods used with the conventional method.

CONCLUSION

The obtained results reveal that the delivered teaching-learning methods make it possible for students to deeper comprehend the elementary concept of data values storage in variables and processing in ALU, RAM and CPU and logic of recursive and sorting programs. It is really learning with fully involvement of brain, hands and eyes because learners can see, hear and feel abstract concept and logic of programming using pictorial/visual representation on multimedia and dry-run of the algorithm flow and logic. It is concluded that use of more senses in teaching learning methods ensures same chance for students with different dominant senses with getting more information, deeper comprehension, better perception and more efficient memorizing using multimedia, play role and dry-run based instructions.

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