Journal of Education and Educational Development
7(1), 119-139, 2020.
DOI: http://dx.doi.org/10.22555/joeed.v7i1.2600

Effect of Simulated Chemistry Practicals on Students' Performance at Secondary School Level

Farkhanda Jabeen
Fatima Jinnah Women University, Pakistan
farkhandajabeen@fjwu.edu.pk

Muhammad Tanveer Afzal
Allama Iqbal Open University, Pakistan
tanveer.afzal@aiou.edu.pk

Abstract

The study was conducted to compare the performance of students working in chemistry laboratory with those working in chemistry laboratory supplemented with simulations at secondary school level. The study was experimental in nature and post-test only control group design was used. The sample comprised of 55 males and 60 female students and 02 Chemistry teachers of class IX of Public schools. At the end of the treatment, practical examination was conducted on the pattern of Peshawar Board of Intermediate and Secondary Education. The scores of both control and experimental groups were compared by using independent sample t-test in three main areas i.e. written, viva voce and notebook. The result of independent sample t test of school No 1(male) indicated that there is a significance difference between the performance of control group (M=8.9, SD=2.13) and experimental group (M=10.5, SD=3.04) at α=0.05 and df=53. The result of independent sample t test of school No 2(female) indicated that there is a significance difference between the performance of control group (M=10, SD=1.91) and experimental group (M=11.7, SD=2.13) at α=0.05 and df=58. The qualitative data was collected by means of interviews from chemistry teachers. Both the interviewees were motivated and showed keen interest in the simulated software. The performance of the students of experimental groups showed improvement results in the rejection of hypotheses that there is no significant difference between the performance of students taught by conventional demonstration in laboratory and laboratory work facilitated with simulation.

Keywords: chemistry practicals, control group, experimental group, performance, simulation

Introduction

The quality of science education has a crucial role in acquiring the leading character among the nations of the world. The development and turn down of any nation depends on the advancement and decline in science respectively. A country that progresses in the discipline of science, industry and technology is more urbanized than the one that lacks progression in the field of science (Faize, 2011). Malik (2007) described that, science courses in Pakistan are over loaded with facts; information and theories. Malik also added that science teachers are not competent enough to teach science courses; the commonly used teaching method is the chalk and talk method; practical aspect in science work is neglected; the course content is out dated; and rote memorization is encouraged. The current era is of science and technology, which demands the conceptual understanding of science (Mathews, 2000). Science has the ability to serve the whole humanity because of its cultural, economic, social and historical aspects. Although, science has brought many problems, but ultimately, it is science that provide solutions of many disasters and safe guard the world (Rowlands, 2008).

Iqbal (2004) in his research study highlights the problems of education in Pakistan which are:

1. Instructional aids are not used.
2. The teachers frequently use conventional lecture method.
3. Lack of discussion and participatory methods.
4. Scarcity of teachers
5. System of examination give more emphasis on rote memorization.
6. The expenses on education is minimal and are not used properly.
7. Laboratories are not well equipped.

Practical work in science plays a vital role in developing scientific knowledge by enhancing scientific skills, attitude and inquiry based learning. Hofstein and Luneta (2003) describe science practical activities as learning experiences where students work together with materials or with models in order to observe and understand the natural world. Science education guidelines and standards suggest that proficiency in science is achieved through learner-centered science instruction that supports conceptual understanding and provides opportunities to learn and practice inquiry (Donovan & Bransford, 2005; National Research Council, 1996, 2012). According to Duschl, Schweingruber, and Shouse (2007), “Students who are proficient in science know, use, and interpret scientific explanations of the natural world, generate and evaluate scientific evidence and explanations, understand the nature and development of scientific knowledge, and participate productively in scientific practices and discourse” (p. 36).

Hofstein (2003) believes that laboratory work is the core of science education. While performing laboratory work, the students get an opportunity to develop their own abilities to design, conduct, interpret and report scientific investigations (Hodson, 1998). Tobin (1990) opines that, “Laboratory activities appeal as a way to learn with understanding and, at the same time, engage in a process of constructing knowledge by doing science” (p. 405).

Hofstein and Mamlok-Naaman (2007) elucidate that the aim of laboratory experiences are to promote goals of science education including the enhancement of students' understanding of concepts in science and its applications; scientific practical skills and problem solving abilities; scientific ‘habits of mind’; understanding of how science and scientists work; interest; and motivation.

Mbajiorgu and Reid (2006) conclude in their research that practical work is a necessary part of theory classes. The laboratory activities help in enhancing conceptual understanding as well as problem solving. Some of the goals for laboratory instructions are as below:

1. Practical skills (including safety, procedures, instruments, observation of methods);
2. Transferable skills (including team working, organization, time management, communication, presentation, information retrieval, data processing, designing strategies);
3. Intellectual stimulation (including explanation of phenomena, developing conceptual knowledge, making connections with the ‘real world’).

Roth (1994) suggests that laboratories have long been recognized for their potential to facilitate the learning of science concepts and skills; this potential has yet to be realized. In the same vein, Gunstone and Champagne (1990) suggest that meaningful learning in laboratory would occur if students were given sufficient time and opportunities for interaction and reflection.

Woolnough (1991) has given the following reasons for failure of practical work at the school level.

1. Overcrowded science classrooms.
2. Lack of teachers having required skills and knowledge for practical work.
3. The teachers have less time to plan for practical activities because they have some other job commitments. The reason for additional job is the poor salary structure for teachers in these countries.
4. The examination system does not emphasize on the practical skills. The theoretical portion carries most of the weight age.
5. There is a shortage of funds for science education besides the lack of science equipment in the science laboratory.

Faize (2011) and Annual report of ASER (2013) identify that the condition of laboratories are poor in Pakistan and lack basic facilities. The major issues relating to laboratory practical are lack of equipment, glassware and chemicals. National Educational policy (2009-2016) also reported that provision of adequate resources including infrastructure, libraries, laboratories, scientific equipment, teaching aids and high speed internet connection remains a challenge. National Educational Policy recommends that modern information and communication technologies are keys to enhance efficiency of educational programs. It will be necessary however to invest in equipment, laboratory facilities and space to cater to the demand of enhanced enrolment. Okon et al. (2006) mention that it is possible to overcome these obstacles by the use of technology-based alternatives.

Flick and Bell (2000) state that science and technology have enjoyed partnership in order to supplement each other. Automation and simulation changes the nature of science laboratories. When well-planned and effectively implemented, science education laboratory and simulation experiences situate students' learning in varying levels of inquiry requiring students to be both mentally and physically engaged in ways that are not possible in other science education experiences. (Lunetta, Hofstein, & Clough, 2007).

Literature Review

The need and demand of science and technology in today's world is well established; therefore, in order to meet the growing challenges, the education system has to gear itself to provide the required training in scientific skills. Khitab, Ghaffar, and Zaman (2013) reiterate that it is the application of science and technology that transformed the world through dramatic advances in every field including medicine, engineering, electronics, aeronautics and others and in more recent times dramatic leaps in computer technology have revolutionized information and communications sector.

Effective technology integration has the ability to promote student interaction, understand scientific concepts and development of spatial intelligence (Hennessy, Deaney, & Ruthven, 2006; Way et al., 2009; Wu & Huang, 2007). Recent investigations suggest that the process of teaching and learning of science may be facilitated by computer-based technologies (Bell & Trundle, 2008; Kim, Hannafin, & Bryan, 2007; Mistler-Jackson & Songer, 2000; Schnittka & Bell, 2009).

Science is practical in nature and psychologists have found that learning by doing is the most effective method for science. It is obvious that the terms, principles their applications and the materials of science become more meaningful by actual use in daily life. The situation of laboratories in general and chemistry laboratories in particular is not satisfactory in public sector schools. Lack of equipment and chemicals are the major issues faced by chemistry teacher and students in the chemistry laboratory. Because of these barriers students only get one chance to perform practicals in the chemistry laboratory. In chemistry laboratory, students perform practicals usually in groups; therefore, sometimes they do not get the opportunity to perform the practicals by themselves. They try to learn just by observing others. The study undertaken by Shami and Hussain (2005) confirm that the availability of physical facilities in laboratories had a significance impact on students' performance.

Simulation is a problem-solving exercise that is undertaken collaboratively and may be solved through a combination of character identification, shared decision making, investigative inquiry and reflective practice within a contextual scenario. The importance of hands-on labs to the technology curriculum cannot be denied. Kim and Fisher (2005) cite several advantages of computer simulations compared to laboratory activities. First, there appears to be important pedagogical advantage of using computer simulations in the classroom. Secondly, the purchase, maintenance and update of laboratory equipment is often more expensive than computer hardware and software. In addition, there is no concern for students' physical safety in the simulation learning environment. Simulation is the means by which science teaching and laboratory work can be improved. Banks (2005) defines simulation as "The imitation of the operation of a real-world process or system over time" (p, 2). By means of simulations, students have the opportunity of repeating any incorrect experiment or to deepen the intended experiences. Moreover, the interactive nature of such teaching method offers a clear and enjoyable learning environment (Ardac & Akaygun, 2004; Jeschke, Richter & Zorn, 2010).

Simulated environment lets students observe the process in more detail as compared to board and chalk activities of the traditional classroom or partially completed experiments of the real laboratory environment (Geban, Askar & Ozkan, 1992; Hounshell & Hill, 1989; Kubala, 1998). Simulations are computational models of real or hypothesized situations that allow users to explore the implications of manipulating or modifying parameters within them (Clark, et al., 2009). Simulations have a great potential to catalyze science teaching. Simulated chemistry software allows students to perform practicals as many times as they wish. It provides them an opportunity for revision and practice. Secondly, the students proceed according to their own pace by using simulated chemistry software to perform practicals. The simulated software is interactive and motivational in nature which grasps the interest of the students.

Simulations are cost effective and save time and energy of both students and teachers. Simulations facilitate learners to observe and also interact with image of natural phenomena that would otherwise be impractical to observe. As a result, they are able to formulate scientifically correct and authentic explanations for those phenomena. Simulations motivate learners with challenges and mold instructions to individual learners' needs and interests. Many studies have reported that laboratory work cannot be properly embedded into traditional chemistry courses for various reasons, such as safety concerns, lack of self-confidence and an excessive amount of time and effort required to conduct accurate experiments (Bryant & Edmunt, 1987; Durmus & Bayraktar, 2010; Elton, 1983; Hofstein & Lunetta, 2004;). Nonetheless, it is not impossible to overcome these obstacles via technology-based alternatives (Okon et al., 2006). Simulations and virtual laboratory can help to make this crucial educational application available to students (Grob, 2002; Jeschke, Richter, & Zorn, 2010; Kumar, Pakala, Ragade, & Wong, 1998; SAVVIS, 2010; Shin, Yoon, Park, & Lee, 2000).

Table 1 shows a comparison of the reasons why chemistry teachers do not include laboratory applications in their teaching and the solutions offered by simulations.

Table 1

Problems Encountered in Laboratories and Solutions offered by Simulation

Reasons for teachers' lack of use of the laboratories	**Alternatives offered by simulations and virtual laboratories**
Safety concerns	Experiments that involve risks in the real environment due to poisonous or unsavory gas releases can be safely performed in virtual laboratory environment / uncontrolled explosions (e.g., NI3) have no real-world consequences, etc.
Lack of Self Confidence	Virtual laboratories help students and teachers with little or no laboratory experience in terms of selecting laboratory equipment, setting up experimental apparatus, and completing the procedure. With the exception of starting the computer or accessing the website hosting the virtual environment software, virtual environments require no prior preparation of laboratory equipment, etc.
Lack of Equipment	As virtual laboratory equipment is not at risk of being broken or lost, users can use virtual laboratories freely. Experiments that cannot be conducted in a real laboratory due to shortages of equipment and materials can be repeated in a virtual lab without any loss.
Time Shortage	Time loss is reduced in virtual laboratories compared to time lost in real laboratories. The experimental procedure in virtual laboratories is similar to that of real laboratories. Understanding and following the experiments is easier in virtual media. After the experiment, it is not necessary to devote time to tidying the virtual laboratory. Students who become accustomed to the virtual laboratory environment can easily repeat the same experiments in the real laboratory environment.
Weaknesses of confirmation method	The interactive format of the virtual laboratory environment presents the problem case by arousing students' curiosity. They are made to put forward and test hypotheses, and are also given the opportunity to make generalizations. Since the subsequent experimental steps in the virtual laboratory are pre-planned, based on *algorithms*, there is no risk of the experiment producing improper results or no results at all. The students are able to research freely within a largely determined framework (Dalgarno, Bishop, Adlong, and Bedgood, 2009; Yu, Brown, and Billet, 2005).

Source: Tatli, Z., & Ayas, A. (2013). Effect of a Virtual Chemistry Laboratory on Students' Achievement. Educational Technology & Society, 16 (1), 159–170.

The role of teachers is an important factor that affects students' performance in the chemistry practicals. It depends on the teachers whether to conduct chemistry practicals and simulation as separate activities or in combination with each other. By supplementing laboratory method with simulation science students may be benefitted. Keeping in view the lack of facilities in science laboratories the researcher intends to supplement the laboratory experiences of the science students by integrating it with simulation.

Smetana and Bell (2012) examine computer simulations to find out its contribution to support science instruction and learning. In their comparative study between traditional games and computer games, they concluded that computer games can be as successful, if not more so, than traditional games in promoting knowledge, developing concepts, developing procedural skills and facilitating conceptual change. The findings of Smetana and Bell (2012) are compatible with those in the survey conducted by Rutten (2012), which focus on implementing games as laboratory activities, concluding that simulations have gained a prominent position in classrooms by enhancing the teacher's repertoire, either as a supplement to traditional teaching methods or as a partial replacement of the traditional curriculum and teacher centered instructions. Nevertheless, they stress that the acquisition of laboratory skills cannot be wholly conducted via simulations. However, in areas where simulations have been widely accepted as a training tool, simulations can play a significant role in making laboratory activities and practicals more effective when offered as pre-lab training tool.

Statement of the Problem

Innovations in teaching aids and teaching strategies are introduced to improve students' performance in science subjects. Science practical imparts knowledge and skills to the students. chemistry laboratories at secondary level lack many facilities. The problems faced by the teachers and students in the chemistry laboratory at secondary levels are lack of equipment, glassware, and chemicals. Another major issue related to performing chemistry practical is casual attitude of teachers and students towards the practical. That's why the performance of students in the practical is not according to the desired standards of science education. The study focused on exploring the ways and means for improving laboratory experiences of students at secondary level by supplementing laboratory work with simulation. Simulations enabled the science students to revise the science practical at home and also learn according to their own pace. Therefore, the researcher conducted study on: Effect of simulated chemistry practicals on students' performance at secondary school level.

Significance of the Study

The study is significant to find ways which may encourage chemistry teachers to supplement their teaching with simulation. The induction of simulation into science laboratory may help to stimulate interest of students and promote their understanding of science. The simulation is also having an element of motivation for the students. This may also help the students to enhance their learning and to meet the demands of the fast moving technological world. The use of simulation in science laboratory enhances the students' performance which boosts school's performance and increases the technological literacy. In order to remain up-to-date teachers need continuous refreshment of knowledge and skills. The use of simulation may especially support distance education. By designing simulated practicals readymade software becomes available to students for revision and practice of practicals at their own pace not only in schools, but also at home. The simulated practicals overcome the obstacle of limited resources and overcrowded classrooms.

This study provides a framework from which further research on simulation in science teaching may be developed.

Hypotheses

To achieve the objectives of the study, the following hypotheses were tested.

H_{01} There is no significant difference between the written performances of students taught by conventional demonstration in laboratory and laboratory work facilitated with simulation.

H_{02} There is no significant difference between the oral performances of students taught by conventional demonstration in laboratory and laboratory work facilitated with simulation.

H_{03} There is no significant difference between the practical performances of students taught by conventional demonstration in laboratory and laboratory work facilitated with simulation.

Methodology

The study was experimental in nature based on post-test only control group design. Randomization is the main advantage of this design. The post-test comparison with randomized subject's controls for the main effects of history, maturation, and pre-testing; because no pre-test is used there can be no interaction effect of pre-test. Another advantage of this design is that it can be extended to include more than two groups. The study comprised three main phases, that is, developmental, training and implementation.

Developmental Phase

The researcher consulted software developer for developing simulated chemistry practicals. The researcher in consultation with subject experts selected ten chemistry practicals for simulation. The researcher developed lesson plan to conduct the practicals in the laboratory facilitated with simulation. The development phase included the following steps:

1. Development of lesson plans
2. Development of prototype for simulation based practicals
3. Quality assurance of prototype by using checklist and pilot testing
4. Revision and improvement of the prototype

Training Phase

The researcher conducted two to three days' orientation session with the chemistry teachers and students for the use of software in the laboratory.

Implementation Phase

The researcher in consultation with the head of the institution arranged eight weeks' laboratory period of chemistry with class IX in selected schools (one male and one female). The class was divided into two groups. The students were randomly placed in control and experimental groups. One of the group performed chemistry practicals in the chemistry laboratory, while the second group performed chemistry practical in the chemistry laboratory supplemented with simulation.

Control group (laboratory method)

1. Control group-I (male = 27), School No 1.
2. Control group-II (female = 30), School No 2.

Experimental group (laboratory work supplemented with simulation)

1. Experimental group-I (male = 28) School No 1.
2. Experimental group-II (female = 30) School No 2.

Post-test related to the ten selected practicals was designed. The post-test was improved with the help of an expert's opinion. The performance of the students was evaluated by two examiners on the pattern specified by Peshawar Board of Intermediate and Secondary Education. The performances of the groups were then compared.

Interview was conducted with chemistry teachers (02) to find out the problems faced by the teacher and students while conducting chemistry practicals in the Laboratory and with the help of simulation.

Population and Sample

Population of the study consisted of all the science students (8934) and the teachers (1087) of secondary schools of Khyber Pakhtunkhwa (KP). The sample comprised two public schools (1 male+ 1 female), chemistry teachers (02) and 115 science students (55 male, 60 female) of class IX of district Peshawar.

Instrument of the Study

The following instruments were used to collect the data.

1. Post-test was conducted to find out the impact of simulation on the performance of students. The major areas/components of the post-test were:
   a) Observation of practical performance
   b) Written work
   c) Viva
   d) Practical note-book

The marking distribution of Peshawar Board of Intermediate and Secondary Education was followed.

2. Interview was conducted to find out the problems faced by teachers and students while conducting practical through simulation.

Findings

Post-test related to the ten selected practicals was designed. The performance of the students was evaluated by two examiners on the pattern specified by Peshawar Board of Intermediate and Secondary Education. The performance of the groups was then compared to find out the difference in performance in following areas.

Comparison of the Control and Experimental Group of School No 1(male)

The class IX (Science Group) of School No. 1, Peshawar consisted of 55 male students. The students were divided into two groups, that is, Control Group-I (27) and the Experimental Group-I (28). The Control Group performed practicals in the chemistry laboratory whereas students of Experimental Group performed practical in chemistry lab supplemented with simulation. The performance of two groups was compared by applying independent sample t-test.

Table 2

Comparison of control and experimental group of School No 1(male)

Group	N	Mean	S.D	t-value
Control Group (M)	27	10.03	1.50	-3.786
Experimental Group (M)	28	11.85	2.01	

Table 2 shows the result of t-test which indicate that there is a significance difference between the performance/scores of control group (M= 10.03, SD=1.50) and experimental group (M=11.85, SD=2.01) of School No 1 at α=0.05 and df =53. Results revealed that experimental group has significantly high scores than the control group.

Comparison of the Control and Experimental Group of School No 2 (female)

The class IX (Science Group) of School No 2 (female) consisted of 60 female students. The students were divided into two groups i.e. Control Group-

II and the Experimental Group-II. The Control Group performed practicals in the chemistry laboratory whereas students of Experimental Group performed practical in chemistry laboratory supplemented with simulation. The performance of two groups was compared by applying independent sample t-test.

Table 3

Comparison of control and experimental group of School No 2(female)

Group	N	Mean	S.D	t-value
Control Group (F)	30	10.23	1.69	-5.84
Experimental Group (F)	30	12.53	1.33	

Table 3 indicates the result of t-test which shows that there is a significance difference between the performance/scores of control group (M= 10.23, SD=1.69) and experimental group (M=12.53, SD=1.33) at α=0.05 and df =58. Results revealed that the scores of experimental group is higher than the control group.

Comparison of Control and Experimental Group in Written Performance

Comparison of performance of the students was made on the basis of written examination. The control group performed practical in the chemistry laboratory whereas the participants of experimental group performed the practical in computer laboratory with the help of simulation.

The control group included both control group I and control group II and experimental group included experimental group I and experimental group II

Control group (57) = control group I (27) and control group II (30)

Experimental group (58) = experimental group I (28) and experimental group II (30)

Table 4

Comparison of Control and Experimental Group on the Basis of Written Work

Group	N	Mean	S.D	t-value
Control Group	57	6.19	1.09	-6.508
Experimental Group	58	7.65	1.30	

Table 4 indicates the result of t-test which shows that there is a significance difference between the performance/scores of control group (M= 6.19, SD=1.09) and experimental group (M=7.65, SD=1.30) on the basis of written work at α=0.05 and df =113. Results revealed that experimental group has significantly high scores than the control group.

Comparison of The Control and Experimental Group in Viva Voce

The comparison of performance of the control and experimental groups were made on the basis of viva voce. The control group performed practical in the chemistry laboratory whereas the participants of experimental group performed the practicals in computer laboratory with the help of simulation.

Table 5

Comparison of Control and Experimental Group on the Basis of Viva Voce

Group	N	Mean	S.D	t-value
Control Group	57	1.97	0.666	-5.25
Experimental Group	58	2.60	0.673	

Table 5 indicates the result of t-test which shows that there is a significance difference between the performance/scores of control group (M= 1.97, SD=.666) and experimental group (M=2.60, SD=.673) on the basis of viva voce at α=0.05 and df =113. Results revealed that experimental group has significantly high scores than the control group.

Comparison of the Control and Experimental Group on the Basis of Notebook

The comparison of performance of the control and experimental group was made on the basis of pratical notebook. The control group performed practical in the chemistry laboratory whereas the participants of experimental group performed the practicals in computer laboratory with the help of simulation.

Table 6

Comparison of control and experimental group on the basis of Notebook

Group	N	Mean	S.D	t-value
Control Group	57	2.00	.000	1.74
Experimental Group	58	1.95	.223	

Table 6 indicates the result of t-test which shows that there is no significance difference between the performance/scores of control group (M= 2.00, SD=.000) and experimental group (M=1.95, SD=.223) on the basis of notebook at α=0.05 and df =113. Results revealed that there is no significant difference in scores of control and experimental groups in term of notebooks.

Finding of Interview of Chemistry Teachers (02) Involved in the Study

An interview was conducted to find out the problems faced by the students and teachers while using simulation. Qualitative data was collected by means of interviews from both male and female chemistry teachers of school No 1 and School No 2 who were involved in the treatment. The purpose of the interviews was to explore the following major aspects related to the study;

1. Problems faced by students and teachers in traditional chemistry laboratory
2. Problems faced by students and teachers while using simulation
3. Students' interest toward the use of simulation
4. Role of simulation in chemistry practicals
5. Suggestions for improvement

Both the respondents used lecture method in the classroom, one of the interviewee reported that sometimes he used demonstration in the laboratory as well. It is important to mention that both the interviewees never used simulation in the classroom. Another finding of the interview was that respondents faced problems related to large students' strength, lack of chemicals and apparatus in the chemistry laboratory in routine. One of the interviewee reported the problems to the administration, whereas the other tries to solve by his own.

Both the respondents reported that the students were very enthusiastic, motivated and show keen interest in simulated software and agreed that simulated software plays an important role in performing practicals. Both the participants quoted that students as well as teachers faced problems while applying simulations in the classroom related to internet speed, hanging of software and electricity failure.

Both the interviewees reported that it seemed difficult to apply simulated software in the present system of education. One of the interviewee recommended to design the simulation software for the complete course and the other one recommended to provide manual and training for the use of simulation for the teachers.

Discussion

This research study attempted to compare the performance of students working in chemistry laboratory supplemented with simulation with those who were working in chemistry laboratory alone. On the basis of comparison of scores of control group and experimental group the null hypotheses that there is no significant difference between the performance of students taught by conventional demonstration in laboratory and laboratory work facilitated with simulation was rejected. Comparison was made in three major areas, that is, written work, viva voce and notebook. Simulation is an effective and interactive software which improves the scores of experimental group thus, indicates that students working in chemistry laboratory with the help of simulation perform better and have clear conceptual understanding. Many researches also support the claim that computer aided instructions and simulations results in better performance of the students. Many researches pointed out that teacher may enhance the learning and conceptual understanding of science students by combining simulations, digital media, modeling tools and virtual collaborative environments. (Higgins & Spitulnik, 2008; Kim et al., 2007; Lee, Linn, Varma, & Liu, 2010; Mistler-Jackson & Songer, 2000; Varma, Husic, & Linn, 2008).

The inclusion of information technology into science instruction enhances students' ability to explore and interpret data, make inferences, model and foster cooperation and teamwork among students (Dani and Koenig, 2008; Dickerson and Kubasko, 2007; Linn, Davis, and Bell, 2004). Simulations create a scenario-based environment where students interact and apply previous knowledge and practical skills to real-world problems (Andreu-Andrés & García-Casas, 2011; Angelini, 2015; García-Carbonell & Watts, 2012). During scenario-based training, the learner acquires important skills, such as interpersonal communication, teamwork, leadership, decision-making, task prioritizing and stress management without any risk (Flanagan, 2004).

The practical scenario of simulation may be carried out individually, in pairs or within a group leading to collaboration, coordination and knowledge sharing among the students and teachers. Different researchers arrive at three recurring conditions for the effective and successful use of simulations and games: the specificity of the game, its integration in the course, and the role of a guiding instructor, which are all conditions in line with Bellotti et al. (2013) findings. The results of the current study indicate that simulations improve the performance of students in written work and viva voce, whereas in the term of notebook there is no significant difference in the performance of control and experimental group.

Conclusion and Recommendations

On the basis of comparison between control and experimental groups in three major areas, that is, written, viva voce and notebook, it is concluded that simulations play an important role in improving the performace of the students by providing an interactive experience. Furthermore, simulations also overcome various barriers faced by the teachers and students in the traditional chemistry laboratories in the presence of appropriate physical facilities.

Following recommendations were made on the basis of research findings and conclusion:

1. Simulated software may be practically implemented at secondary school level to facilitate learning.
2. Physical facilities especially stand by electric power generator and high speed internet may be provided for the application of simulated software.

References

Ardac, D., & Akaygun, S. (2004). Effectiveness of multimedia-based instruction that emphasizes molecular representations on students' understanding of chemical change. *Journal of research in science teaching*, *41*(4), 317-337.

Banerji, R., Bhattacharjea, S., & Wadhwa, W. (2013). The annual status of education report (ASER). *Research in Comparative and International Education*, *8*(3), 387-396.

Banks, J. J. S. Carsonll., B. L. Nelson., & D. M. Nicol. (2005). *Discrete event system simulation*. New Jersey: Prentice Hall.

Bell, B. S., & Kozlowski, S. W. (2008). Active learning: effects of core training design elements on self-regulatory processes, learning, and adaptability. *Journal of Applied Psychology*, *93*(2), 296.

Bell, R. L., & Trundle, K. C. (2008). The use of a computer simulation to promote scientific conceptions of moon phases. *Journal of Research in Science Teaching, 45*(3), 346-372.

Bellotti, F., Kapralos, B., Lee, K., Moreno-Ger, P., & Berta, R. (2013). Assessment in and of Serious Games: An Overview. *Advances in Human-Computer Interaction*, Volume 2013, Special issue. http://dx.doi.org/10.1155/2013/136864

Clark, D. B., Nelson, B., Sengupta, P., & D'Angelo, C. (2009). Rethinking science learning through digital games and simulations: Genres, examples, and evidence. Paper commissioned for the National Research Council Workshop on Gaming and Simulations, October 6-7, Washington, DC.

Dahar, M. A., & Faize, F. A. (2011). Effect of the availability and the use of science laboratories on academic achievement of students in Punjab (Pakistan). *European Journal of Scientific Research*, *51*(2), 193-202.

Dani, D. E., & Koenig, K. M. (2008). Technology and reform-based science education. *Theory into Practice, 47*(3), 204-211.

Dickerson, J., & Kubasko, D. (2007). Digital microscopes: Enhancing collaboration and engagement in science classrooms with information technologies. *Contemporary Issues in Technology and Teacher Education*, *7*(4), 279-292.

Donovan, M. S., & Bransford, J. D. (2005). *How students learn: Science in the classroom*. Washington, DC: National Academies Press.

Duschl, R. A., Schweingruber, H. A., & Shouse, A. W. (Eds.). (2007). *Taking science to school: Learning and teaching science in grades K-8. Washington, D.C.*: The National Academies Press.

Flick, L., & Bell, R. (2000). Preparing tomorrow's science teachers to use technology: Guidelines for science educators. Contemporary Issues in Technology and Teacher Education [Online serial], *1*(1).

Flick, L., & Bell, R. (2000). Preparing tomorrow's science teachers to use technology: Guidelines for science educators. *Contemporary Issues in Technology and Teacher Education*, *1*(1), 39-60.

Geban, O., Askar, P., & Özkan, Ï. (1992). Effects of computer simulations and problem-solving approaches on high school students. *The Journal of Educational Research, 86*(1), 5-10.

Government of Pakistan, (2009). *The national education policy 2009*, Ministry of Education.

Gunstone, R. F., & Champagne, A. B. (1990). Promoting conceptual change in the laboratory. In E. Hegarty-Hazel (Ed.), *The student laboratory and the science curriculum* (pp. 159–182). London: Routledge.

Hennessy, S., Deaney, R., & Ruthven, K. (2006). Situated expertise in integrating use of multimedia simulation into secondary science teaching. *International Journal of Science Education, 28*(7), 701-732.

Higgins, T. E., & Spitulnik, M. W. (2008). Supporting teachers' use of technology in science instruction through professional development: A literature review. *Journal of Science Education and Technology, 17*(5), 511-521.

Hill, C. E., Loch, K. D., Straub, D., & El-Sheshai, K. (1998). A qualitative assessment of Arab culture and information technology transfer. *Journal of Global Information Management, 6*(3), 29-38.

Hodson, D. (1998) *Teaching and learning science: Towards a personalized approach*. Buckingham: Open University Press.

Hofstein, A., & Mamlok-Naaman, R. (2007). The laboratory in science education: the state of the art. *Chemistry Education Research and Practice, 8*(2), 105-107.

Hofstein, A., & Lunetta, V. (2003). The Laboratory in science education: Foundation for the 21st century. *Journal of Science Education, 88*(1), 28-54

Iqbal, A. (2004). *Problems and prospects of higher education in Pakistan* (Unpublished doctoral dissertation). Institute of Education and Research, University of Arid Agriculture Rawalpindi, Pakistan.

Jeschke, S., Richter, T., & Zorn, E. (2010). Virtual labs in mathematics and natural sciences. In *International conference on technology supported learning & training: Online educa Berlin* (pp. 183-204). Retrieved from http://www.ibi.tuberlin.de/diskurs/veranst/online_educa/ oeb_04/Zorn%20TU.pdf

Khitab, U., Ghaffar, A., & Zaman, A. A. 2013. An investigative study of the construction of low cost material by secondary science teachers. *Word Applied Science Journal, 28*(10), 1427-1436

Kim, M. C., Hannafin, M. J., & Bryan, L. A. (2007). Technology-enhanced inquiry tools in science education: An emerging pedagogical framework for classroom practice. *Science Education, 91*(6), 1010-1030.

Kim, Y. C., & Fisher, M. E. (2005). Singular coexistence-curve diameters: Experiments and simulations. *Chemical Physics Letters, 414*(1-3), 185-192.

Kozma, R., Chin, E., Russell, J., & Marx, N. (2000). The roles of representations and tools in the chemistry laboratory and their implications for chemistry learning. *The Journal of the Learning Sciences, 9*(2), 105-143.

Kubala, T. (1998). Addressing student needs: Teaching on the internet. *The Journal, 25*(8), 71-74.

Lee, H. S., Linn, M. C., Varma, K., & Liu, O. L. (2010). How do technology-enhanced inquiry science units' impact classroom learning? *Journal of Research in Science Teaching, 47*(1), 71-90.

Linn, M. C., Bell, P., & Davis, E. A. (2004). Specific design principles: Elaborating the scaffolder knowledge integration framework. In In M. C. Linn, E. A. Davis, & P. Bell (Eds.), Internet environments for science education (pp. 315–340). London: Routledge.

Lunetta, V. N., Hofstein, A., & Clough, M. P. (2003). Learning and teaching in the school science laboratory: An analysis of research, theory and practice. *Handbook of Research on Science Education, 2*.

Malik, U. (2007). Exploring science education in Pakistan. *Journal of the American Physical Society, 16*(9). 34-39.

Mathews, M. R. (2000). *Times for science education.* New York: Kluwer.

Mbajiorgu, N., & Reid, N. (2006). *Factors influencing curriculum development in chemistry*. Hull: Higher Education Academy.

McCoy, E. D., & Bell, S. S. (1991). Habitat structure: The evolution and diversification of a complex topic. In *Habitat structure*. Dordrecht: Springer.

Mistler-Jackson, M., & Butler Songer, N. (2000). Student motivation and Internet technology: Are students empowered to learn science? *Journal of Research in Science Teaching, 37*(5), 459-479.

National Research Council. (2006). *America's lab report: Investigations in high school science*. New York: National Academies Press.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press.

Okon, M., Kaliszan, D., Lawenda, M., Stoklosa, D., Rajtar, T., Meyer, N., & Stroinski, M. (2006). Virtual laboratory as a remote and interactive access to the scientific instrumentation embedded in grid environment. In *2006 Second IEEE International Conference on e-Science and Grid Computing (e-Science'06)* (pp. 124-124). IEEE.

Roth, W. M. (1994). Experimenting in a constructivist high school physics laboratory. *Journal of Research in Science Teaching, 31*, 197–223.

Rouse, D. P. (2007). Computer-assisted instruction: An effective instructional method. *Teaching and Learning in Nursing, 2*(4), 138-143.

Rowlands, S. (2008). The crisis in science education and the need to enculturate all learners in science. In Petroselli, C. L. (Ed.), *Science education issues and development* (pp. 117-1). New York: Nova Science Publisher.

Shami, P. A., & Hussain, K. S. (2005). *Basic education in Pakistan* (No. 181). Academy of

Educational Planning and Management, Ministry of Education.

Tatli, Z., & Ayas, A. (2013). Effect of a virtual chemistry laboratory on students' achievement. *Educational Technology & Society*, *16*(1), 159–170.

Tobin, K. G. (1990). Research on science laboratory activities; In pursuit of better questions and answers to improve learning, *School Science and Mathematics, 90,* 403-418.

Varma, K., Husic, F., & Linn, M. C. (2008). Targeted support for using technology-enhanced science inquiry modules. *Journal of Science Education and Technology*, *17*(4), 341-356.

Woolnough, B. E. (1991). Setting the scene. In B. E. Woolnough (Ed.), *Practical science* (pp. 3–9). Milton Keynes: Open University Press.