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# Impact of Hands-on Activities on Students' Achievement in Science: An Experimental Evidence from Pakistan

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**Abstract:** This study aimed to investigate the effectiveness of hands-on activities on 8th grade students' achievement in science. The study was conducted on 342 students (145male, 197 female) of which 169 were assigned as experimental group and instructed by hands-on activities, while the 173 were assigned as control group and instructed by the traditional method. For the study, Science Achievement test was used to collect the data. The data were analyzed by using Independent Sample t-test through SPSS. The results indicated that there was a significant difference between the means of the students' science achievement in favour of the experimental group. The results of this study are important especially for developing countries that cannot afford to use expensive science equipments to make the students physically active and engaged in learning science.

**Key words:** Hands-on activities · Science achievement

## INTRODUCTION

Globalization has created a sense of competition among the nations of the world in every sphere of life. It has also accelerated the pace of development. In the contemporary world scenario, different nations are striving for their survival and advancement to play the leading role in this global village. This advancement depends on the quality of education provided to the nation. Specifically, sound education in science and technology has played a remarkable role in achieving the world leading role.

Science has two-fold nature (a) Systematic body of knowledge); and (b) ways of investigating and thinking, that is, the product and the process nature of science. Both these aspects of science combine to form knowledge of science [1]. In its real sense, science provides unique training of observation and reasoning. It makes people careful and systematic by training them in observing, recording, inferring and predicting about the phenomena occurring in the environment.

Acquiring information, developing methods of thinking, applying science principles and forming attitudes are general categories of objectives related to science learning [2,3]. Science curriculum at different levels is designed keeping in view the above objectives.

Researchers advocate that creativity and higher order learning may be achieved by the use of hands-on activities which will eventually lead to achieve the aforesaid objectives of science [4]. Especially at the primary level these activities may prove an effective supplement for the teachers who lack in science background knowledge [5].

Activities which provide students with the opportunity to switch over freely and continuously between collecting, processing and interpreting the data, may prove fruitful and effective for a better learning [6].

The research on methodologies and strategies for science teaching has evidenced that students in activity based programs learn better than students in traditional textbook based programs [7]. It has been observed that learning situations that require more active involvement of students in multiple ways to process information may increase their learning [8].

It is obvious from the research that there is a shift in emphasis from text book recitation to physical interaction with materials, having the spirit of active learning, causing a change in that what we can accept as understanding. The ultimate goal of science teaching is to bring students to a stage where they delight in being involved in learning science and feel committed to

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continuing its study [9]. There are various factors affecting the students' learning in science. One of these is hands-on science activities.

Hands-on science is not completely a new idea in the literature but it broadens the meaning from the past terms such as "laboratories" to cover a variety of settings i.e. from laboratories to classrooms. Descriptions of science education have shifted from vocabulary and text materials to activities. Teachers are now seeking to recognize what students are learning as a consequence of busy hands [10]. The term hands-on is used commonly in science education. It means that teacher should do more than lecturing about science. It allows the students to experience science by doing it involving using the hands. Like many other terms in educational practice, these terms have no standard definition that has one meaning for all practitioners. It may also be defined as any activity that allows the learner to handle, observe or operate a scientific process. In hands-on science activities, learners interact with materials and equipments [11].

Hands-on science activities may also be defined as a variety of activities that may or may not be actual experiments, such as observation or measurements, not necessarily carried out in laboratories [12]. Generally hands-on science activities are defined as the activities that allow the students to handle, manipulate or observe the scientific processes [11]. In these hands-on activities, students interact with materials to observe scientific phenomena. Flannery [13] states that hands-on science foster the mind in more basic ways by extending the links between the brain and the hand. Different memories have been identified for different functions. Those are auditory, visual, tactile and body motor functions [14]. It implies that any information which utilizes all four memories would be a stronger and easily retrievable. Because hands-on activities utilize all these memories, therefore the information gathered through these, would be more powerful and easily retrievable.

Science educators have attempted to classify hands-on science activities into different categories. One dimension addressed by various experts in science education is inquiry. It has been argued by prominent educators and psychologists that science is an inquiry based subject and should be taught in that fashion. Within the inquiry dimension, distinctions might be made keeping in view the level of inquiry involved. Lumpe and Oliver [11] differentiated the verification activities from inquiry activities that inquiry activities that verification activities are those activities in which the learner knows the result of the activity prior to conducting the activity while in inquiry activities; the learner has no understanding of the concept or phenomenon prior to conducting of activity.

The abstraction of science content and teaching put unpleasant effects on learners. Currently, almost all major science curriculum development projects have emphasized on hands-on practical activities as both an effective and enjoyable way of learning science content. These activities provide the students concrete experiences as far as possible to reduce the abstraction [15]. Effectiveness of hands-on activities in learning science has long been hotly debated and accepted by science education community [16].

The need of concrete experiences in science instruction is advocated because they enhance students' learning and provide a more authentic view of science [17]. He believed in doing first and reading and writing later. According to [14] John Dewy was of the strong opinion that experiences specifically hands-on activities are vital in educational process. Physical operations provide feedback of learning that allows learners to see it happen.

Hands-on activities are effective learning experiences. Research has evidenced that hands-on approach in science improves understanding of concepts resulting in better achievement score and success in science subject area. In a study conducted by [14] on 50 eighth graders in teaching technical concept on geodesic domes, it was found that there existed a significant difference between learning with and without hands-on activities. They concluded that hands-on activities are effective in learning any applicable concept. It was found in a study conducted by [18] that the students who were engaged in hands-on activities everyday or once a week scored significantly higher on a standardized test of science achievement than the students engaged in hands-on activities once a month or never. Young and Lee (2005) conducted a study on 399 fifth graders. The study provided evidence that the students who were taught through science kits outperformed as compared to the students taught science without using science kits [19].

In a study conducted by [20] on 123 fifth and sixth graders from a middle school, it was found that the students involved in hands-on activities scored significantly better than those taught through teacher centered experiments. Similar results were found in the study conducted by [21] on a sample of 611 seventh and eighth grade students enrolled in middle school science, it was concluded that near daily implementation of hands-on activities yield the greatest positive impact on students' achievement.

As Pakistan is lagging behind in science and technology as compared to the developed countries and Pakistani students' achievement in science is low as compared to the students of those countries, therefore, there is dire need to explore the ways and means by which Pakistani students' achievement in science may be improved. This study attempts to meet this need, anticipating the improvement of teaching learning science in Pakistan.

**Research Questions:** This study addresses the following research questions:

- Is there any significant difference between mean achievement scores in science of the students taught through hands-on activities and those taught by traditional method?
- Is there any significant difference between mean achievement scores in science of male students and female students taught through hands-on activities?
- Is there any significant difference between mean achievement scores in science of the male students taught through hands-on activities and those taught by traditional method?
- Is there any significant difference between mean achievement scores in science of the female students taught through hands-on activities and those taught by traditional method?

## Methodology

**Research Design:** Quasi experimental design [22] was followed in the study. Intact sections of class VIII were taken as experimental and control groups. As there is no pre-test, the scores of sampled students in the subject of science in their $7^{th}$ class annual examination were used to determine whether there exists any initial difference between the experimental and control groups but it was found that there existed no significant difference in science achievement between the experimental and control group. As the study was initiated at the start of session of VIII class, so the score of students' in science gained in their VII class annual examination was used to determine whether there existed any initial difference between experimental and control groups on their achievement in science. The independent sample t-test was applied through SPSS on the science achievement score of experimental (M=40.37, SD=15.88) and control group (M=43.14, SD=16.12) but no significant difference in science achievement between control and experimental group was found, $t(340) = -1.67$, $p = .095 > 0.05$.

**Sample:** Purposively four schools from district Khushab (two boys' and two girls' schools), with the condition of having at least two sections of class VIII, being taught the subject of science by the same teacher or the teachers of equal qualification and experience were selected. The reason for purposive sampling is that the researcher himself is a public sector school teacher and it was difficult for the researcher to supervise the study or teach himself beyond a reachable distance. Due to this restraint four schools within a radius of 20 kilometers were purposively selected. The students of two sections of class VIII of these schools each comprised sample of the study. One section from each school was randomly assigned to experimental group and the other to control group.

**Procedure of the Study:** Eight chapters from science text book grade VIII were selected and twenty four concepts from these chapters were taught through hands-on activities. Hands-on activities suggested in these chapters were used as well as some additional hands-on activities were developed by the researcher to strengthen students' understanding of the selected science concepts. Both classes of the each school i.e. control and experimental, were taught by the same teacher or the teachers of equal qualification and experience. The control classes were taught solely in the traditional way of instruction, whereas the experimental classes were exposed to hands-on-activities relevant to the selected concepts twice a week in addition to traditional instruction (teacher centered method of instruction with teachers' main focus on lecturing, dictating main points and students' rote memorization without any kind of practical activity on students' part or any sort of demonstration by teachers).

As both the experimental and control classes in each school were taught through the same teachers, the students in both classes were almost equal in ability (t-value was insignificant for grade seven scores in science), the school environment was almost the same, the internal validity issues were assumed to be covered. So far as the external validity issue is concerned, all the participants of the study were assigned to experimental and control groups randomly. All the four selected schools were similar to other public sector schools throughout the district in all respects; teachers' qualification, ability, cultural background and socio-economic status of the students and so on. So it was expected that the results of the study would be generalizable for the whole population.

All the groups were post-tested only for achievement. Experimentation period covered 12 weeks.

**Achievement Test:** A multiple choice achievement test in science was developed by the researcher. This test was developed in accordance with curriculum objectives. It comprised of 55 multiple choice items. The face and content validity of the test was determined through expert opinion. A panel of three experts having qualification and experience in both the content and assessment areas reviewed and rectified the test. The improved version was undergone pilot study. As a result of item analysis, 3 items were discarded and the final version contained 52 items. The alpha reliability of the test was computed 0.93. Only first three levels of Blooms' taxonomy i.e. knowledge, comprehension and application were incorporated in the test.

**Data Analysis:** Independent samples t-test was applied to analyze the data with the help of SPSS.

## RESULTS

Data were exposed to an independent samples t-test which revealed that there was a significant mean difference between the experimental ($M$ =34.31, $SD$ = 4.32) and control ($M$ = 30.67, $SD$ = 3.80) groups, $t$ (367) = 8.59, $p < 0.01$, with effect size (0.90), indicating that the student who were taught science using hands-on-activities performed better on science achievement test than those students who were taught without inclusion of hands-on-activities. Hence, it can be concluded that hands-on-activities enhance students' achievement in science.

As shown in table 2, gender wise comparison of experimental group on science achievement score was made through independent samples t-test. A non-significant difference was found between the two gender groups, t (186) = 0.936, p = 0.351 > 0.01. Hence, it can be concluded that hands-on-activities had the same effect on both male and female students' science achievement.

Table 3 depicts the results of independent samples t-test that was run to compare the mean science achievement scores of male experimental and male control group students. The difference was significant, t (153) = 5.82, $p < 0.01$, indicating that the male experimental group students (M = 34.66, SD = 4.60) performed better than their counter parts—male control group students (M = 30.68, SD = 4.60) on science achievement test.

Table 1: Comparison of Experimental and Control Group on Achievement in Science

| Group | N | Mean | SD | *df* | T | *P* | Effect size |
|---|---|---|---|---|---|---|---|
| Experimental | 188 | 34.31 | 4.32 | 367 | 8.59** | 0.000 | 0.90 |
| Control | 181 | 30.67 | 3.80 | | | | |

*p<0.01

Table 2: Gender wise Comparison of Experimental Group on Achievement in Science

| Group | N | Mean | SD | *Df* | T | *p* | Effect size |
|---|---|---|---|---|---|---|---|
| Male | 77 | 34.66 | 4.60 | 186 | .936 | 0.351 | 0.14 |
| Female | 111 | 34.06 | 4.11 | | | | |

*p<0.01

Table 3: Comparison of Male Respondents of Experimental and control Groups on Achievement in Science

| Group | N | Mean | SD | *df* | T | *P* | Effect size |
|---|---|---|---|---|---|---|---|
| Experimental | 77 | 34.66 | 4.60 | 153 | 5.82** | 0.000 | 0.94 |
| Control | 78 | 30.68 | 3.90 | | | | |

*p<0.01

Table 4: Comparison of Female Experimental and control Groups on Achievement in Science

| Group | N | Mean | SD | *df* | T | *P* | Effect size |
|---|---|---|---|---|---|---|---|
| Experimental | 111 | 34.06 | 4.11 | 212 | 6.32** | 0.000 | 0.87 |
| Control | 103 | 30.66 | 3.74 | | | | |

*p<0.01

Independent samples t-test (Table 4) revealed that there was a significant difference between mean science achievement scores of female experimental and female control group students, t(212) = 6.32, $p < 0.01$, indicating that female experimental group students (M = 34.06, SD = 4.11) performed better than female control group students (M = 30.66, SD = 3.74) on science achievement test.

## CONCLUSIONS AND DISCUSSION

It is evident from the study that inclusion of hands-on activities has significant effect on students' science achievement. Students instructed by these activities gained a higher achievement in science. This finding is consistent with previous studies [14, 19, 20, 21, 23-27, and 28], but in contrast with the findings of [15]. They concluded that although hands-on activities have positive effect on students' attitudes but no significant difference between experimental and control groups was found in science achievement.

It may be attributed to the fact that the activities were quite limited in number (only two) and experimentation period was too short (six periods of 50 minutes each). Moreover, contrary to our research finding, Areepattamannil (2012) found that student investigations and hands-on activities had negative effects on science achievement of school students in Qatar [29]. In the same way [30] found that student-centered activities did not contribute to explain achievement measures positively. It may be due to context specific orientations.

Gender wise comparison shows that there exists no significant difference between the post test achievement score of male and female students of experimental groups. It means that hands-on activities are equally effective to raise the achievement score in science irrespective of the gender of the students. These findings are similar to the previous studies [31, and 32]. However, [20, and 33] found that female students benefitted more as a result of experiencing hands-on activities. It may be due to the fact that in their study, activities were related to biology and according to [34] female students perform better than male students in biology. Some other studies have also evidenced that performance of female students in science is better than their male counterparts [35, 36, and 37]. But according to [38] sex differences in achievement in science do exist but smaller than it is assumed, generally they tend to favour males.

Comparison between male students of experimental and control groups shows that there existed a significant difference between the groups. It reflects that hands-on activities have a significant effect on male students' achievement in science. The results of this study are consistent with the previous studies [20, and 25].

Comparison between female students of experimental and control group also shows a significant difference among the groups. It indicates that inclusion of hands-on activities have positively affected the female students' achievement in science. These findings confirm the previous findings of the studies [20, 25, and 33].

The overarching conclusion of this study is that students' science achievement can be improved through the use of hands-on activities. Several international studies on science achievement have shown that Pakistani students are performing poor in science as compared to the other nations of the world. Therefore, teachers should select and execute such hands-on activities that may enhance their interest and understanding in science which will eventually result in higher motivation and achievement in science. This study has the implication for science teachers who want to bridge the gap of their students' achievement in science, to enable them to compete internationally, for their own better future and prosperity of the country.

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