A Comparative Study to Find Effectiveness of Teaching Biology Through Low-Cost material as Teaching Aid and Traditional Method of Teaching at Secondary Level

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Abstract
The study was conducted to investigate a comparative study to find the effectiveness of teaching biology through low-cost materials as teaching aid and traditional method of teaching at secondary level. The objectives of the study were, a) to find the effectiveness of low-cost material as teaching aid on the academic performance of the students in the subject of Biology at secondary level, b) to find the effectiveness of traditional methods on the academic performance of the students in the subject of Biology at secondary level, and c) to compare the effectiveness of low-cost material as teaching aid and traditional methods on the academic performance of the students in the subject of Biology at secondary level. A Pretest–Posttest Equivalent Group Design was used in the study. Forty-six students from class 10th from The Educators Dhamial Campus, Rawalpindi were taken as a sample for the study through paired random sampling technique. An experimental research design was used for the conduction of the study. For data collection, assessment sheets were developed. To measure the performance of the students, statistical techniques such as t-test (independent and paired) and Chi Square were applied to analyze the collected data. Data analysis revealed that the experimental group scored significantly better on post-test than on pre-test in the learning of biology. The students also showed high level of interest and involvement. The use of low-cost materials in models proved to be effective in increasing academic achievement of biology students. On the basis of findings, it was recommended that biology teachers use low-cost materials as
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a teaching aid. This study may be significant for science students and teachers.

Keywords: Biology, Low-Cost Material made Models, Secondary Education

Introduction
The essential character of education for individual growth and social development is now accepted by everyone. Broadly speaking, education refers to any act or experiences that have a formative effect on the personality of an individual. Such a view of education will include all of life’s experiences. Life involves constant change and continuous modification of experience. Ideas change; attitudes and skills undergo alteration. Education is the process of assisting a child in adapting to a changing world (Adeniyi, 2005). Educational technology enables the availability of education and improvement in the quality of education. Development in technology brings about changes and shifts in educational goals, which, in turn, stimulate the emergence of new techniques. Information and communication technology (ICT) cover different types, enabling users to receive, share, and exchange information (Sivakumar, 2014). Children at the beginning of the last century were taught in a more rigid and stereotyped way. Education was considered as a process of the transmission of knowledge. The children were tested many times, but those tests were neither concerned with theoretical understanding nor useful for meaningful learning. The teacher did not use any other method of teaching for improvement of students’ learning (Bransford, Brown, & Cocking, 2012). The development of modernized skills in complex and complicated environments differentiates a line between high academic achievers and low academic achievers. The innovative skills included innovation, creativity, problem-solving, critical thinking, collaboration, and communication (Isola, 2010). The current study aimed to find out if new teaching with low-cost model methods is similar to or more effective than the conventional methods used for teaching biology at the secondary level.

Learning through models is one of the new approaches which can help teachers make teaching according to the needs of the time. It is an approach that focuses on students and gives them priority for learning activities. In student-centered learning, students are delicately heard, patiently listened to, and considerably given preference. The classroom activities are determined and developed according to their interests, abilities, and needs. There is a great change between teacher and pupil roles. Now the teacher’s role has shifted from transmitter to learning facilitator, collaborator, and coach. The teacher is not a primary source of information, but he or she becomes a knowledge explorer, knowledge enhancer, and co-learner. The learner is provided with options and is assigned responsibilities for their own learning. There is also a great change in student roles with time. Students are no longer silent, passive listeners to teachers’ lectures, reproducing knowledge and acting as solitary individuals, but rather an active participant in the entire teaching-learning process, providing knowledge and sharing it with others through cooperation and mutual understanding (Faize, 2011). In Pakistan, majority of the teachers use Lecture-demonstration method. A few teachers use low-cost materials with good results for teaching science subjects.

Literature Review
Dewey (1938) considered education as a reconstruction or organization of experience,
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adding meaning to experience that leads to the ability to direct the course of experience. Education starts from birth to death, and the school is not the only agency of education. Though the school has a greater influence in educating the child, other social agencies such as home, religion, press, radio, library, television, and so on supplement its work. Emphasis on the inculcation and fostering of scientific spirit, knowledge, principles, and factors and on framing scientific methods. Low-cost teaching materials refer to materials prepared with simple materials that cost very little by involving teacher and student. Inexpensive material could be prepared easily with little or no money to make learning effective, comprehensive, and fascinating. The biology teacher, with a certain amount of skill and enthusiasm, can replace many pieces of apparatus with an adequate, if unconventional, improvised substitute. Low-cost teaching materials have the advantage of offering a learn by doing approach to the teaching-learning process. When teachers and students plan, prepare, or create their own educational materials, they constantly manifest pride and pleasure in utilizing them. Effective biology teaching depends on three factors, teacher, equipment, and materials. Locally produced low-cost equipment, teaching materials, or models can serve the needs of the teacher, the student, and the curriculum more effectively and are easier to maintain (Grantt, 2011). The main task of the teacher is to develop low-cost teaching materials by using locally available materials. The teacher should be an active participant in preparing low-cost teaching aids. A teacher by himself or with the help of students may carry out the process. To design an effective low-cost teaching material, the teacher should have a thorough knowledge of the objectives and biology concepts. The teachers should have sufficient knowledge to provide learning experiences based on locally available resources and environmental conditions. To enhance the learning process, biology teachers who have a real interest in the field prepare their own teaching materials with the help of available resources. The quality and effectiveness of these low-cost teaching materials can be improved with enough encouragement from superiors, parents, and the community (UNESCO, 1978). The traditional method of teaching is when a teacher directs students to learn through memorization and recitation techniques thereby not developing their critical thinking, problem-solving, and decision-making skills. Traditional teaching is a teacher-centered approach. Most researchers consider the traditional method of teaching as teaching through recitation and memorization techniques, in which the teacher's role is centered. In traditional teaching methods, teacher does not require any special technical knowledge and can focus more on his subject to impart the best knowledge to the students. Low-cost teaching materials indicate materials prepared with natural or man-made materials that cost very low by engaging teachers and students. Modest material could be prepared easily with low or no money to make learning effective, inclusive and delightful. A biology teacher with a certain number of skills and passion can replace many segments of apparatus with a competent, if unusual, improvised replacement. Low-cost teaching materials have the significance of offering a learn by doing method to the teaching-learning process. There are different ways to classify and categorize low-cost materials. For instance, UNESCO (1978) identified the following five ways:

i. The available materials in the natural environment as well as scarps/discards from commercial and domestic use. They may be freely and easily available. Some examples are seeds, shells, bottle caps, packing materials, fused bulbs, etc.
ii. The available materials which are easily accessible in the environment but the purchase of which could be within the reach of the schools. Examples in this category could be a battery, bulb, wire, etc.

iii. The available examples of prototype materials prepared by teachers and specialist for possible wider dissemination. Examples are charts, periodic tables, simple models or kits which are either distributed by government agencies or sold commercially.


v. Materials such as radio programs, television programs, videotapes and films which most often are made for wider utilization to justify the high cost. The use of these materials in the classroom depends largely on the teacher’s skill and competence.

In the 21st century, modern information and communication technologies (ICTs) also provide an opportunity for low-cost teaching and learning. The use of open-source and free software that is made for educational purposes are now becoming common in most institutions, provided that the needed infrastructure is in place (Naser, 1993).

There are different approaches for locally produced equipment in different countries.

Possible types of production are:

- Production by teachers and students.
- Establishment of central production units in the country.
- Central development and assembly of equipment and kits.
- Decentralized development and production.
- A combined approach (probably the most frequent).

In general, for developing and using low-cost materials, it is necessary to consider the level at which the materials are used (such as elementary school, secondary school, and colleges). The materials should also be judged based on specific criteria such as the amount of money required, the involvement or participation of various groups (such as teachers, students, community, specialists, and so on), the environment from which the materials are obtained, and their utilisation (Rotimi et al., 2012). No education can survive in isolation because the world has become globalized. The interaction of people across borders and across continents, their communication, their economic ties, and their job opportunities have stunned the educationists who remained aloof and tried a solo flight. The chances and challenges, opportunities and choices provided by the international community in the fields of business commerce, availability and access to technology, cultural values, and identity (National Education Policy 2009). Education must be upgraded to the requirements of today’s modern world. It needs to provide real-life skills, encourage and support student talents. Relevant education is vital to the well-being of any society, but it is especially crucial for the survival and progress of developing countries with an increasing number of young people. Education, at all levels, should respond to the needs of society (Rotimi et al., 2012).

Ilfat (1998), entitled "Activities Based on Low-Cost Materials (Equipment, Glassware, Chemicals) in Teaching Chemistry at Secondary School Level in Pakistan," found that in view of the effectiveness of the use of low-cost materials in chemistry teaching, Mukama (2011) conducted research on the use of low-cost materials in teaching and learning of mathematics. It was found out that group and other associated methods were being used in schools that had numerous teaching and learning strategies. Khitab (2012) organized research on the
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Development of Low-Cost Learning Materials for the Teaching of Chemistry at Secondary Level. Engida (2012) conducted research on the topic "Development of low-cost educational materials for chemistry" and tries to highlight the principles and approaches towards the development of low-cost chemistry materials from locally available materials. Singh & Kaur (2012) conducted research on the use of low-cost or no-cost teaching materials by elementary school teachers in teaching of science. The present experimental study was carried out to compare the effectiveness of low-cost materials for learning of biology at secondary level. Such studies are needed to be conducted in other subject areas such as physics, chemistry, and social sciences. The overall result of this study was derived from the significant difference between the performance of experimental and control groups after the utilization of low-cost materials in models. In light of evidence that teaching of biology through models developed with low-cost material is an effective teaching method, Statistical analysis between the experimental and control groups concluded that the experimental groups showed better performance due to the use of low-cost materials in models. The experimental group produced higher order thinking that is knowledge, comprehension, analysis, synthesis, application, and evaluation in the content area.

Objectives of the Study
Following were the objectives for the study
i. To find the effectiveness of Low-Cost material as teaching aid on the academic performance of the students in the subject of Biology at secondary level
ii. To find the effectiveness of traditional method on the academic performance of the students in the subject of Biology at secondary level
iii. To compare the effectiveness of Low-Cost material as teaching aid and traditional method on the academic performance of the students in the subject of Biology at secondary level

Hypothesis
Following null hypothesis were formulated for the current study
i. There is no significant difference in the means of academic performance of students of control and experimental group.
ii. There is no significant difference in the means of academic performance of students taught through low–cost material and traditional method.

Delimitations
The current study was delimited only to the Biology students at secondary level. Courses and lessons which involved or required use of modeling or modeling technique were only considered for gathering the information. Topics taught through low-cost models were limited to human heart, human eye and human brain.

Methodology
The study was experimental in nature. The pre-test post-test equivalent group design was used. The symbolic representation of the design is:
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\[
\begin{align*}
R_E &= O_1 - T - O_2 \\
R_C &= O_3 - O_4 \\

\text{d}_{RE} &= O_2 - O_1 \\
\text{d}_{RC} &= O_4 - O_3 \\
D &= \text{d}_{RE} - \text{d}_{RC}
\end{align*}
\]

(Farooq & Tabassum, 2018)

The pre-test post-test equivalent group design is the most common experimental research design (Cook & Wong, 2008). In this design, the experimental group takes part in some type of treatment or intervention, which can consist of single or multiple training sessions.

**Pretest-Posttest Equivalent Group Design**

<table>
<thead>
<tr>
<th>Pre-test</th>
<th>Control Group</th>
<th>No Treatment</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test</td>
<td>Experimental Group</td>
<td>Experimental Treatment</td>
<td>Post-test</td>
</tr>
</tbody>
</table>

Low-cost material was independent variable and students' academic achievement was considered as dependent variable. The control group was taught by traditional method and the experimental group was taught through models prepared by the researcher from low-cost materials.

On the basis of pretest scores, 46 students were further divided into experimental and control group having equal number of students. Two different biology teachers having equal qualification and teaching experience taught both experimental and control group. Low-cost models were made by the researchers for teaching the selected three topics to the students of biology. All the models were hand made by the researchers which show a clear depiction of different body parts which are better and explained by the teachers using a model. All models were made using low-cost materials. Illustration and description of materials used to make the models are presented below.

*Figure 1*: Illustration of human brain
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Researchers utilized football, cake plate and rope to make model of human brain. Different parts of brain were explained through different colors.

*Figure 2: Illustration of human eye*

Researchers used rubber ball as base of eye, used board marker, plastic bottle and cake plate for model of human eye.

*Figure 3: Illustration of human heart*

Researchers utilized empty bottle of oil and pipe to make model of human heart.

**Population and Sampling**

The population of the study included students studying Biology at secondary level. By using paired random sampling technique, forty-six students of class 10th enrolled in “The Educators Dhamial Campus”, Rawalpindi were selected as the sample of the study. Students who were studying biology were included in the sample. These students were divided into two groups having 23 students in each group.

**Data Analysis Technique**

Data collected through pretest and posttest was analyzed by using the means, standard deviations, difference of means and independent t-test. Significance of difference between mean academic achievement scores of post-tests was tested at 5% level of significance by applying t-test. Pretest and posttest were developed for the collection of the data. There were

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40 multiple choice questions were in both tests. These multiple-choice questions were selected from the topics that had been taught during the treatment. The detail of data analysis is as under:

**Table: 1 Performance of the students in the topic: Human Brain**

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>Mean</th>
<th>S. D</th>
<th>Std. Error Mean</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental group</td>
<td>23</td>
<td>30.70</td>
<td>7.516</td>
<td>1.567</td>
<td>2.848</td>
<td>0.718</td>
</tr>
<tr>
<td>Control group</td>
<td>23</td>
<td>24.04</td>
<td>8.304</td>
<td>1.731</td>
<td>2.021</td>
<td>0.718</td>
</tr>
</tbody>
</table>

Table: 1 shows that the mean value of experimental group was 30.70 while in control group it was 24.04. It shows that the academic performance of experimental group was much better than control group. The calculated t-value was 2.848 while table value was 2.021. Similarly calculated p-value was 0.726 while table value was 0.718. These t value and p value showed that a significant difference between experimental and control group. Thus, the null hypothesis “there is no significant difference in the means of academic performance of students of control and experimental group” was rejected.

**Table: 2 Performance of the students in the topic: Human Eye**

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>Mean</th>
<th>S. D</th>
<th>Std. Error Mean</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental group</td>
<td>23</td>
<td>30.91</td>
<td>7.516</td>
<td>1.597</td>
<td>3.322</td>
<td>0.816</td>
</tr>
<tr>
<td>Control group</td>
<td>23</td>
<td>23.52</td>
<td>8.304</td>
<td>1.472</td>
<td>2.021</td>
<td>0.718</td>
</tr>
</tbody>
</table>

Table: 2 shows that the mean value of experimental group was 30.91 while in control group it was 23.52. It shows that the academic performance of experimental group was much better than control group. The calculated t-value was 3.322 while table value was 2.021. Similarly calculated p-value was 0.816 while table value was 0.718. These t value and p value showed that a significant difference between experimental and control group. Thus, the null hypothesis “there is no significant difference in the means of academic performance of students of control and experimental group” was rejected.

**Table: 3 Performance of the students in the topic: Human Heart**

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>Mean</th>
<th>S. D</th>
<th>Std. Error Mean</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental group</td>
<td>23</td>
<td>30.96</td>
<td>7.516</td>
<td>1.419</td>
<td>5.165</td>
<td>0.718</td>
</tr>
<tr>
<td>Control group</td>
<td>23</td>
<td>20.65</td>
<td>8.304</td>
<td>1.402</td>
<td>2.021</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Table: 3 shows that the mean value of experimental group was 30.96 while in control group it was 20.65. It shows that the academic performance of experimental group was much better than control group. The calculated t-value was 5.165 while table value was 2.021. Similarly calculated p-value was 0.718 while table value was 0.05. These t value and p value showed that a significant difference between experimental and control group. Thus, the null hypothesis “there is no significant difference in the means of academic performance of students of control and experimental group” was rejected.
Table: 23 shows that the mean value of experimental group was 30.96 while in control group it was 20.65. It shows that the academic performance of experimental group was much better than control group. The calculated t-value was 5.165 while table value was 2.021. Similarly calculated p-value was 0.05 while table value was 0.718. These t value and p value showed that a significant difference between experimental and control group. Thus, the null hypothesis “there is no significant difference in the means of academic performance of students of control and experimental group” was rejected.

Conclusion
“A Comparative Study to Find Effectiveness of Teaching Biology Through Low-Cost material as Teaching Aid and Traditional Method of Teaching at Secondary Level” was an experimental study. It was concluded that the experimental group showed better result as compared to the control group as it was taught through traditional method.

It means that there was a significant difference between the academic performance of experimental and control group. The academic performance of the students taught through low-cost material was much better than the control group after teaching the topic of “Human Brain”. It was further concluded that there was a significant difference between the academic performance of experimental and control group. The academic performance of the students taught through low-cost material was much better than the control group after teaching the topic of “Human Eye”.

It was also concluded there was a significant difference between the academic performance of experimental and control group. The academic performance of the students taught through low-cost material was much better than the control group after teaching the topic of “Human Heart”. Results showed that slow learners taught through models showed better score on post-test than the pre-test which proved that models prepared with low-cost material were effective in increasing slow learners learning in biology subject. Models with the utilization of low-cost material were found to be more effective for teaching science specially biology as reflected through the difference between academic achievement scores of pre-test and post-test. The study reported a range of positive outcomes during implementation of low-cost material in the development of models. Therefore, science specially biology teachers may use low-cost material to improve the academic achievement of students.

Recommendations
The study showed that the performance of the students taught through the low-cost material teaching aid was much better than the students taught through traditional method.

It is recommended that teaching science is an activity-based approach for which benevolent relationships between teachers and students must be developed. Teachers must encourage and show cooperation with their students to utilize low-cost materials for developing models. Moreover, they must engage all students equally in their work. It is observed that in many institutions, teachers transmit their knowledge without activating their students’ energy for learning. Learning mostly takes place when the learner becomes active and engages himself in the learning process. Creativity leads to promotion and better achievement in science subjects. Therefore, all teachers must establish an atmosphere for active participation of students to generate new ideas that may be useful in solving problems, communicating with
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others, and entertaining ourselves and others. The scientific knowledge that we are utilising nowadays must have creativity in its vision for an individual to participate in the competitive world of tomorrow. Therefore, it is suggested to the text book developers that particular focus might be given to including hands-on activities with low-cost materials in the curriculum for higher secondary level to ensure the higher creativity of the students at this level.

It is also recommended that these designs may develop a positive attitude towards biology along with students' creativity and their relationship for better achievement in biology. Students find the curriculum difficult to understand because it is based on rote memorization of the text material. Consequently, they mostly rely on rote memorization and do not gain conceptual understanding. This scenario may be made better by including interesting low-cost materials. The teachers may be trained in the proper way for the fabrication of activities with low-cost materials and their utilization in the class. Both teachers and students should be encouraged to use low-cost materials in the classrooms to learn by doing. Summarizing, the text book's material may be developed in such a way that teachers and students automatically follow the steps of the teaching and learning process through activities with low-cost materials.

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