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Effect of Teaching Methods on "Higher Order Thinking Skills" of Elementary Level Science Students

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Abstract: *The effect of two different teaching methods on "Higher Order Thinking Skills" (HOTS) of elementary-level science learners was analysed in this research. This is an emerging field in research globally as well as in the Pakistani scenario. The research design used for this project was a "pre-test and post-test control group design". Two sections comprising 40 students were selected randomly and were taught with two different teaching methods; the "experimental group" engaged by "Problem Based Learning Method" (PBLM) while the "control group" dealt with the "Traditional Method" (TM). The academic performance of the students was evaluated through an Achievement Test of Science (ATS). Post analysis data study showed that the performance of the "experimental group" engaged by the "problem-based learning method" was better on "higher order thinking skills" at elementary level science. The study findings may be helpful for science teachers, teachers training institutions, and other educational stakeholders.*

Key Words: Problem Based Learning Method (PBLM), Traditional Method (TM), Higher Order Thinking Skills (HOTS), Achievement Test of Science (ATS)

Introduction

Teaching is a very complex and influential art and needs to take suitable and flexible steps during the teaching activity. More innovative initiatives are required for quality teaching; until one meets these standards, there will be no quality teaching (Tileston, 2003).

That is why, in the current global scenario, all the nations are trying to evolve their education systems with modern and updated teaching methods and techniques (Ronis, 2008).

To follow the global trend, the Government of Pakistan also focused on the 2009 Education Policy from "teaching" to "learning" that the curriculum in the future will concentrate on ensuring student absorption (Government of Pakistan, 2009).

In the student centre approach, "Problem-Based Learning" is a globally emerging method. It is the classroom approach that puts learning in a uniform order. In this approach, students get to know about many open-ended problem-solving experiences (Ronis, 2008).

Educationists have elaborated the word PBL in various ways. Hmelo-Silver (2004) described the PBL in these terms, "it is a teaching method in which students work together to find possible solutions to problems".

The "problem-based learning method" is very vital for teaching multiple subjects due to its similarity with human brain function, "Problem-based learning Method" is effective in teaching students because it strengthens aspects of brain learning (Ronis, 2008). Two main categories of human cognitive skills can be formed; "low order thinking skills" and "higher thinking skills". "Lower Order Thinking

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Skills" are the initial stages of Benjamin Bloom's taxonomy of educational objectives, namely, knowledge, understanding & application. "Higher Order Thinking Skills" are the final stages of this taxonomy, analysis, synthesis & evaluation (Moore & Stanley, 2010).

Cognitive skills are essential to the educational process. Human imagination can influence the effectiveness of learning capability and its pace, so the learning process is totally dependent on cognition. Students who have thinking minds not only show healthy progress in education but are also not affected by the debacle they are faced with because they can work out the solution to the problem (Yee et al., 2011). "Higher order thinking skills" is a thinking quality that needs greater energy besides memory capacity. "Higher Order Thinking Skills" are students' skills that are introduced when students are confronted with alien issues, unpredictabilities, questions, or situations (King, Goodson, & Rohani, 2013).

Since problem-solving learning is mainly used in the teaching of science-based subjects, therefore, it seems very appropriate to explore and apply a "problem-based learning method" in dealing with subjects in our domain, but before that, we should have a brief look at past practices of science teaching in Pakistan. It was observed that until 1950 science was not taught at the grass root levels. In 1959 Science Education Commission was established, and the commission recommended compulsory science education in classes VI-VIII in the early sixties, and science education was implemented in I - VIII classes (Iqbal & Mahmood, 2000)

Statement of the Problem

This research project was designed to investigate the effect of teaching methods on the "higher order thinking skills" of elementary-level science students.

Significance of the Study

Educational experts of different countries have been devising problem-based learning curricula for different subjects at their institutions for the purpose of developing a scientific approach to solve the problems at campuses and in real life, too. Many researchers have been conducting research at secondary and higher levels all over the world. The elementary level is an important one because it will become the base for students in further stages of education. With the intention that students may become familiar with this approach, the researcher has selected the elementary level for conducting this research. Keeping in view the importance of science at the elementary stage for in-depth understanding, advancement of problem-solving skills, classroom-related and lifelong problem-solving skills, problem-based learning (PBL) is very vital. This study would be ready to lend a hand to the teachers and would be advantageous to the students. It would be a constructive study for educators and curriculum developers. So the research will help all the stakeholders of education to tackle the important issues regarding education.

Objectives of the Study

1. Investigate the students' Achievement Level of 8th Grade Science engaged in "Problem Based Learning Method" and taught by Traditional Method.
2. Compare the effect of teaching methods on "Higher Order Thinking Skills" of 8th Grade Science Students.

Hypotheses

H_{01}: "There is no significant difference of pre-test scores before intervention on students' academic achievement of 8th-grade science between Control Group and Experimental Group".

H_{02}: "There is no significant difference of post-test scores of Control and Experimental Groups after intervention regarding the effect of Problem Based Learning Method on the achievement level of students of 8th-grade science".

H_{03}: "There is no significant difference between pre-test and post-test scores of Control Group regarding the effect of

Traditional Method on the achievement level of students of 8th-grade science".

H_{04}: "There is no significant difference between pre-test and post-test scores of the experimental group regarding the effect of Problem Based Learning Method on students' achievement level of 8th Grade Science".

H_{05}: "There is no significant difference between control and experimental group pre-test scores of higher order thinking skills".

H_{06}: "There is no significant difference between control and experimental group post-test scores of higher order thinking skills".

Literature Review

Education plays a crucial part in the development of a nation. School education is a continuous investment in national planning for development. Transformation to increase the standard of education must be a priority for educational institutions. Major social problems should be reflected in the curriculum to focus on the development of multiple skills like problem-solving, questioning practices, critical thinking, guided reading skills, and collaborative work among students (Savery, 2015).

In recent times, educationists have been designing modern teaching methods to teach effectively. Each has its own characteristic in various subjects. Sometimes one teaching method might be found suitable for one subject, but another method may not be suitable for that particular subject. Many methods are employed in the educational process, for example, collaborative approach, project approach, lifestyle, computer-assisted education, problem-based learning process, etc. Each teaching method has its benefits and disadvantages. Here is a brief description of just two of them.

Traditional Method

The traditional method of teaching is the most commonly used teaching method in our school education. This is a systematic approach for teachers. However, students only listen and do not do much most of the time.

Problem-Based Learning Method

Problem-based learning is based on a student-centred approach and emphasises real-life problems and issues. The problems under study should be valid, challenging, difficult and unexpected. The activities implemented should be vast, and they must be evaluated on specific standards that can assess students' capabilities for higher-level knowledge application (Hmelo-Silver et al., 2007).

PBLM can change the conventional teaching paradigm philosophy into 21st-century teaching. Thus, like other advanced countries, it will enhance the quality of the educational system in quality. In the classroom, learning may become more interesting through an effective teaching method. Studies in line with this research showed that an effective teaching methodology is the most influential element which definitely influences the learners' performance in education. (Missildine, Fountain, Summers, & Gosselin, 2013). Furthermore, the use of different teaching approaches is always helpful for the students in understanding the process of problem-solving (Schultz, Duffield, Rasmussen, & Wageman, 2014).

PBLM was introduced as the latest approach in the field of education. It deals with real-life problems rather than content. Students are supposed to solve problems actively, and teachers as the facilitator. PBLM helps to enhance the progress of lifelong learning skills, i.e. reflective, open-minded, active and critical learning. Likewise, the PBLM help in acquiring skills of interpersonal communication, team working and problem-solving (Tan, 2021).

What Are Higher Thinking Skills?

Thinking is an act of understanding that requires space and time. We do a lot of thinking. We can probably see the way we do in our daily life. Deciding what clothes to wear and remembering to take our keys when we leave the house requires careful thought. Students' ability to recognise, remember,

understand and apply their knowledge in real-life problems comes under lower order thinking skills, and these skills are not sufficient for the professional learning process. For this purpose, the student passed through the learning process of higher order thinking skills to have knowledge of synthesis, analysis and evaluation. Lower-order thinking skills provide a basic platform for learning higher-order thinking skills (Brookhart, 2010).

Why Is Higher Thinking Ability Important?

Systematic thinking is essential for development. No explorer has ever found anything new by following in the footsteps of those who were there before. Lower order thinking skills help to understand the knowledge and higher order thinking skills enable to interpret and apply knowledge to reach a conclusion (Barak & Dori 2009). This exposes other areas of knowledge and knows how to re-transfer, use and integrate to create a new and improved version. If you are committed to learning, growing and changing constantly, it is important that you are committed to developing your higher thinking skills (Elser, 2008).

The Role of Teachers in Developing High Cognitive Skills

Our country's education system focuses on regular testing, and in such cases, learning is almost like a repetition of meaningless information without access to information. The teacher is always forced to compile information even though they know that many students may not fully understand it and may not keep it for long. The role of the teacher is therefore important in providing information as it should be the responsibility of all teachers to provide education using high cognitive techniques, so the learner can think critically and develop problem-solving skills and decision-making skills (Heong et al., 2011). A well-informed and well-educated teacher should be familiar with the facts that before introducing students to a higher learning path, the teacher should equip his or her student with the ability to think before asking him or her to think. The teacher's role is not simply to help the learner learn to appreciate the important information he or she receives. The teacher should realise that the depth of knowledge is more important than the integration of the lesson and should therefore plan his or her lesson and keep these points in mind (Shukla & Dungsungnoen 2016).

Science Teaching for Students at the Elementary Level

In teaching science, the main purpose is to develop problem-solving skills among students. Students discover scientific concepts and intricate programs and are able to identify and describe their conditions. Students understand the scientific concepts by asking different questions instead of rote learning. Students used scientific methods to understand a process and solve a problem. Students critically analysed facts, figures and concepts and gave reasoning on the results. Students learn different scientific skills and understand science & technology relationship and their impact on society. The scientific method leads students to think critically, understand their problems and solve them; in the recent century significance of science increased. Science introduced wonderful technological advances in comparison with time, extending the prehistoric years to the previous century. This is an era of science and technology, and no nation that ignores the importance of science as a subject can perform better in all fields of life (Lunenburg, 2011).

Methodology

This research was experimental in its design. “Pre-test and Post-test control group design" was used to explore the Effect of Teaching Methods on "Higher Order Thinking Skills” of elementary-level science students. Eighty students in 8th grade were drawn from a randomly selected school. A pre-test was conducted, and on the results of the pre-test, both groups were equated and equally distributed into experimental & control groups subsequently. One group was named "control", & the second "experimental". The data of the

pre-test was saved and recorded to be compared with the data collected through Post-test. The researcher herself taught both groups along with the science teacher. The treatment group was engaged in a "problem-based learning method", and the control group dealt with the "traditional method" for fourteen weeks. In the end, a Post-test was conducted to assess the achievements of both groups. The results obtained through pre and post-tests from both groups were compared and analysed to explore the effect of Teaching Methods on the "Higher Order Thinking Skills" of elementary-level science students.

Pretest & Posttest Control Group Design employed for this research is described below:

Control Group	R	O	X1	_____	O
Experimental Group	R	O	X2	_____	O

Abbreviations

R	Random assignment of group
O	Pre-test & Post-test
X2	Treatment (Use of PBLM)

Data Analysis and Interpretation

Objective1: Investigate the students' Achievement Level of 8th Grade Science engaged in the "Problem Based Learning Method" and taught by the Traditional Method.

H_{01}: "There is no significant difference of pre-test scores before intervention on students' academic achievement of 8th-grade science between Control Group and Experimental Group".

Table 1. Comparative analysis of both groups on Pre-Test Scores

Test	Groups	N	Mean	SD	T	df	Sig.
Pre-Test	Control Group	40	12.65	2.86	-1.836	74.994	.070
	Experimental Group	40	13.72	2.34			

Data were analysed through an independent sample t-test. It was revealed from data analysis of table 3 that the difference was not significant between both groups, i.e. control group with values (M=12.65, SD=2.86) & experimental group with values (M=13.72, SD=2.34) of pre-test scores at the level of significance $p \leq 0.05$ with ($t = -1.836$, $p = .070$). The null hypothesis "There is no significant difference of pre-test scores before intervention on students' academic achievement of 8th Grade Science between Control Group and Experimental Group" is accepted.

H_{02}: "There is no significant difference of post-test scores of Control and Experimental Groups after intervention regarding the effect of Problem Based Learning Method on the achievement level of students of 8th-grade science".

Table 2. Comparison of both groups on post-test scores

Test	Groups	N	Mean	SD	T	df	Sig.
Post-Test	Control Group	40	15.22	3.99	-14.930	70.085	.000
	Experimental Group	40	31.60	5.66			

Data were analysed through an independent sample t-test. It was revealed from data analysis of table 3 that the difference was significant between both groups, i.e. control group with values (M=15.22, SD=3.99) & experimental group with values (M=31.60, SD=5.66) of post-test scores at the level of significance $p \leq 0.05$ ($t=-14.930$, $p=0.000$). After analysis hypothesis "There is no significant difference between post-test scores of control and experimental groups afterintervention regarding the effect of Problem Based Learning Method (PBLM) on the achievement level of students of 8th Grade

Science of Control Group and Experimental Group" is rejected.

H_{03}: "There is no significant difference between pre-test and post-test scores of Control Group regarding the effect of Traditional Method on the achievement level of students of 8th-grade science".

Table 3. Comparison of Scores achieved by Control Group in Pre & Post-Tests

Group	Tests	N	Mean	SD	t	df	Sig.
Control Group	Pre-Test	40	12.65	2.86	-4.586	39	.000
	Post-Test	40	15.22	3.99			

Data was analysed through paired sample t-test. The test was applied at a $p \leq 0.05$ level of significance ($t=-4.586$, $p=0.000$). It was revealed from data analysis of table 4.3 that the difference was significant between both tests, i.e. pre-test with values ($M=12.65$, $SD=2.86$) & post-test with values ($M=15.22$, $SD=3.99$) obtained from the control group. Therefore hypothesis "There is no significant difference between pre-test and post-test scores of Control Group regarding the effect of Traditional Method on the achievement level of students of 8th-grade science" is rejected.

H_{04}: "There is no significant difference between pre-test and post-test scores of the experimental group regarding the effect of Problem Based Learning Method on students' achievement level of 8th Grade Science".

Table 4. Difference of Pre & Post-Tests Scores of Treatment Group

Group	Tests	N	Mean	SD	T	df	Sig.
Experimental Group	Pre-Test	40	13.72	2.34	-19.474	39	.000
	Post-Test	40	31.60	5.66			

Data was analysed through a dependent sample t-test. The test was applied at a $p \leq 0.05$ level of significance ($t=-18.10$, $p=0.000$). It was revealed from data analysis of table 5 that the difference was significant between both tests, i.e. pre-test with values ($M=13.72$, $SD=2.34$) & post-test with values ($M=31.60$, $SD=5.66$) of the treatment group. Therefore hypothesis "There is no significant difference between pre-test and post-test scores of the experimental group regarding the effect of Problem Based Learning Method on students' achievement level of 8th Grade Science" is rejected.

Objective 2: Compare the effect of teaching methods on "Higher Order Thinking Skills" of 8th Grade Science Students.

H_{05}: "There is no significant difference between control and experimental group pre-test scores of higher order thinking skills".

Table 5. Comparison of both groups on Pre-Test Scores (Higher Order Thinking Skills)

Test	Groups	N	Mean	SD	T	df	Sig.
Pre-Test	Control Group	40	5.12	1.39	-1.148	78	.254
	Experimental Group	40	5.50	1.51			

Data were analysed through an independent sample t-test. It was revealed from data analysis of table 6 that the difference was not significant between both groups, i.e. control group with values (M=5.12, SD=1.39) & experimental group with values (M=5.50, SD=1.51) of pre-test scores at the level of significance $p \leq 0.05$ with (t = -1.148, p = .254). The null hypothesis "There is no significant difference between control and experimental group pre-test scores of higher order thinking skills" is being accepted.

H_{06}: "There is no significant difference between control and experimental group post-test scores of higher order thinking skills".

Table 6. Difference between both groups on Post-Test Scores (Higher Order Thinking Skills)

Test	Groups	N	Mean	SD	T	df	Sig.
Post-Test	Control Group	40	15.30	3.93	-14.944	69.45	.000
	Experimental Group	40	31.60	5.66			

Data were analysed through an independent sample t-test. It was revealed from the data analysis of table 7 that the difference was not significant between both groups, i.e. control group with values (M=15.30, SD=3.93) & experimental group with values (M=31.60, SD=5.66) of post-test scores at level of significance $p \leq 0.05$ with (t = -14.944, p = .000). The null hypothesis "There is no significant difference between control and experimental group post-test scores of higher order thinking skills" is being rejected.

Conclusions

On the basis of the findings of this research, conclusions drawn as follow:

1. The achievement of both groups is almost similar in the pre-test. The groups did not show differences significantly in their achievement. The hypothesis "There is no significant difference of pre-test scores before intervention on students' academic achievement of 8th Grade Science between Control Group and Experimental Group." is accepted.
2. The treatment group's achievement was better than the control group in results obtained from the post-test. Both groups differ significantly in their mean scores. The null hypothesis "There is no significant difference of post-test scores of control and experimental groups after intervention regarding the effect of Problem Based Learning Method (PBLM) on the achievement level of students of 8th Grade Science." was rejected.
3. The control group differs significantly in its achievement on the results obtained from pre and post-test scores. This indicates the importance of the traditional method of teaching science at the elementary level. "There is no significant difference between pre-test and post-test scores of control group regarding the effect of the traditional method on the achievement level of students of 8th Grade Science." was rejected.
4. The experimental group differs significantly in its achievement results obtained from pre and post-tests. It was concluded in favour of the "problem-based learning method". "Problem-based learning method" of teaching proved its significance for teaching science subjects at the elementary level. "There is no significant difference between pre-test and post-test scores of the experimental group regarding the effect of Problem Based Learning Method (PBLM) on students' achievement level of 8th Grade Science." was rejected.
5. The performance of both groups on results obtained from the pre-test regarding the effect of the "problem-based learning method" & traditional method on "higher order thinking skills" did not indicate any difference. Therefore, the hypothesis "There is no

significant difference between control and experimental group pre-test scores of higher order thinking skills." was accepted.

6. The performance of the experimental group was found to be better than the achievement of the control group post-test regarding higher order thinking skills. The groups differ significantly in their results obtained from post-test. Therefore, the hypothesis "There is no significant difference between control and experimental group post-test scores of higher order thinking skills." was rejected.
7. Control group and experimental group don't differ significantly in their achievement in the mean scores on the pre-test in the cognitive domain. Both the groups showed the same level of performance in the cognitive domain at the time of grouping.
8. Difference in results obtained from the post-test of both groups showed that the "problem-based learning method" of teaching is more effective in the teaching of science subjects at the elementary level.

Recommendations

After analysis of the data and conclusions of this study, the following recommendations have been formulated:

1. "problem-based learning method" increases students' participation and reduce the role of the teacher; therefore, it is strongly proposed to follow the "problem-based learning method" at all level in teaching science subjects.
2. One of the most important aspects of PBLM is the development of students' ability to actualise their experience in other situations; therefore, the "Problem-based learning method" is suitable for the teaching-learning process in social sciences as well as natural sciences.
3. To enhance the student's ability to analyse, synthesise and evaluate different concepts, the "problem-based learning method" proved a very useful teaching method. This method made them able to have their own opinion and develop their ability to assess and evaluate, so it is highly recommended for the students in schools, especially in science subjects.
4. It is highly recommended further research on PBLM in context with other disciplines.

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