Physics Teaching Methods: Scientific Inquiry Vs Traditional Lecture

Dr Ashiq Hussain
University of Education
Pakistan

Muhammad Azeem
Punjab Education Assessment System (PEAS)
Pakistan

Azra Shakoor
Doctoral Research Scholar
University of Education, College Road, Township
Lahore, Pakistan

Abstract

This research study compared scientific inquiry method and traditional lecture method of teaching. Scientific inquiry was divided in the three levels—guided scientific inquiry, unguided scientific inquiry and combination or mixed (guided & unguided) scientific inquiry. The major objective of this study was "to study the effect of three levels of scientific inquiry method and traditional method of teaching physics on students' performance and their proficiency to apply the physics knowledge in real life situations. The pretest post test control group experimental design is used in this research study. Three experimental groups were taught by scientific inquiry. One of the experimental groups was taught by guided scientific inquiry; Second group was taught by unguided scientific inquiry and third was taught by combination scientific inquiry and fourth group was taught by traditional method. Groups were randomly chosen for the treatment. Pretest was used groups equivalence and posttest was used to compare students' achievement in physics. Research explored that there is significant effect of guided, unguided and combination scientific inquiry on the students' achievement than traditional physics teaching method and their proficiency to apply the concepts of chemistry in real situations.

Keywords: Teaching Methods, Assessment,

1. INTRODUCTION

The importance of students' learning to put their latent skills to optimal use is self-evident as education inculcates decision-making abilities in students. Learning of different subjects may not yield similar results as there are many factors effects students achievement but teaching methods almost have same effect on students learning.
Teaching of physics is facing dilemma for teachers as well as students. Physics curricula should inculcate creative thinking and critical analysis in students. Mathematical foundations must be a part of curriculum to develop the concepts and the ideas of physics. Physics students outfitted with crystal-clear concepts should have the proficiencies to solve problems, in the classroom, laboratory, , practical problems related to industry, and house-hold real life. Pakistan is also facing problems in teaching of physics at undergraduate level. Teaching of Physics suffers because due to limited resources, equipment and latest physics books.

Problems in teaching physics can be minimizing by selected suitable teaching method. If one learns physics concepts properly, one should be able to solve unseen problems .This is the major difference in teaching strategies of Pakistani institutions versus US institutions. The former focus on definitions and derivations, whereas the later emphasize on concept building (Kamal, Arif, 2003). In Pakistan due to economic constraints stress is on theory and laboratories are inadequate. There is no awareness of the importance of physics in the Government officials and among the people (Rashid, Khalid, 2005). Scientific inquiry method brought new developments in the field of education. According Exline, Joe, (2004) scientific inquiry method implies involvement of students that leads to understanding. Furthermore, students' involvement in learning implies possessing skills and attitudes that permit to seek resolutions to questions and issues while you construct new knowledge. "Inquiry" is defined as "a seeking for truth, information, or knowledge -- seeking information by questioning.". Student inquiry is defined as a versatile activity that involves making observations, posing questions, examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of the student's experimental evidence; using tools to gather, analyze and interpret data; proposing answers, explanation, and predictions; and communicating the results.

Inquiry requires of assumptions, use of critical and logical thinking, and consideration of alternative explanations (Exline, Joe, 2003). The present study was intended to scrutinize how the presence of scientific inquiry might affect undergraduate student's achievement in physics. In this study Atkin & Karplus (1962) Learning Cycle is the bases of the Scientific Inquiry method.

2. SIGNIFICANCE OF THE STUDY

The upshots of this research may be beneficial for physics teachers, students, curriculum developers, educational authorities, and in general educational system. Physics teachers may be able to select different appropriate apparatus, tools and materials to promote their teaching by emphasizing on strategies and instructional approaches in the context. Physics teacher may be engaged students in investigations by ensuring a safe working environment make available science tools, materials, media, and technological resources. Students may be proficient in framing and solving the problems associated with inquiry activities to solve problems in context of daily life. Students may be prepared for the lifelong challenges by developing competence.

3. HYPOTHESES

Following are seven null hypotheses for the study:

H01: There is no significant difference of scientific inquiry method of teaching and Lecture method of teaching on students' achievement in physics.
H02: There is no significant difference of guided scientific inquiry method of teaching and Lecture method of teaching on students' achievement in physics.
H03: There is no significant difference of unguided scientific inquiry method of teaching and Lecture method of teaching on students' achievement in physics.
H04: There is no significant difference of combine scientific inquiry method of teaching and Lecture method of teaching on students' achievement in physics.
H05: There is no significant difference of guided scientific inquiry method of teaching and Lecture method of teaching on students' ability to apply knowledge of physics concepts in real life.
H06: There is no significant difference of unguided scientific inquiry method of teaching and Lecture method of teaching on students' ability to apply knowledge of physics concepts in real life.
H07: There is no significant difference of combined scientific inquiry method of teaching and Lecture method of teaching on students' ability to apply knowledge of physics concepts in real life.
H08: There is no significant difference of combined scientific inquiry method of teaching and guided scientific inquiry method of teaching on students' ability achievement in physics.
H09: There is no significant difference of combined scientific inquiry method of teaching and unguided scientific inquiry method of teaching on students' achievement in physics.
H010: There is no significant difference of guided scientific inquiry method of teaching and unguided scientific inquiry method of teaching on students' ability achievement in physics.

4. METHODOLOGY: POPULATION, SAMPLING, AND INSTRUMENTATION

a. POPULATION AND SAMPLING

All 10^{th} grade students of public institutions in Faisalabad District studying physics comprise target population while all 10^{th} grade students of Govt. higher secondary school Chak Jhumra District Faisalabad studying physics is the accessible population for this study. 175 male physics students out of 279 male physics students of 10^{th} grade of age 15-17 years were selected. Selected students were available for the intelligence test and socio-economic status performa. 123 students were matched on their scores obtained on the intelligence test and socio-economic status performa, four equivalent groups of each 30 students using matching by pairs technique were formed so that each subject in the control group had a match in the three experimental groups. All the matched pairs participated in the study.

b. INSTRUMENTATION

Following three instruments were used in the study.
1. Physics Proficiency test
2. Students' Intelligence test
3. Socio-economic status performa

MCQs type Physics proficiency test was developed by the researcher with the help of senior subject specialists from Punjab Education Assessment System (PEAS). Test Items closely reflected the objectives of the research.

Validity and reliability was ensured through tryout and pilot testing along with content alignment analysis. Content validity was determined by the expert judgment. Physics proficiency test was used as pretest and post test to measure students' proficiency of the physics topics taught to them during the experiment. Student's intelligence in the form of raw scores was measured by using J.C. Ravens' Standard progressive matrices. The researcher developed socio-economic status perfoma to measure the socio-economic status of their parents. Socio-economic status perfoma was validated through expert opinion. Numerical values were assigned to each indicator and total score on socio-economic status perfoma was calculated for each sampled student.

c. PROCEDUTER

Four groups each of 30 students were randomly chosen. Pretest was conducted before experiment to check the group's initial equivalence. The mean of four groups was approximately 20. It validate that all groups were almost same on the pretest. Three experimental groups were taught by the guided scientific inquiry, unguided scientific inquiry, combination scientific inquiry and the fourth control group was taught by the lecture method. Four science teachers of same qualification were selected for the study. Three teachers were trained to teach three experimental groups and fourth teacher assigned to control group of the study for the period of three months. Students of three experimental groups passed through the exploration, concept introduction, concept application three phases of the learning cycle. Students of the first experimental group were given the treatment of guided inquiry and they passed through exploration, concept introduction, concept application the three phases of the learning cycle under the guidance of the teacher. It was teacher directed. Students of the second experimental group were given the treatment of unguided inquiry and learned through their involvement and action.

In this group the teacher released the responsibility and it was student directed. The third experimental group was given the treatment of combination (guided/unguided) inquiry, the teacher in this group acted as a facilitator and asked or posed questions, gave ideas. In this approach guided inquiry was followed by unguided inquiry. The main focal point of this cram of research was to actively engage physics students using scientific inquiry in the class. Students were divided into small groups to build up each other's ideas for better understanding. The usages of different apparatus/tools over the three months period provide evidence of advances in the student's scientific inquiry ability. Throughout the study four groups covered the same subject matter. Pretest was conducted as post test to four groups to compare their achievement in physics at the end of the experiment

5. DATA ANALYSIS AND INTERPRETATION

The data was collected by using students' intelligence test and socio -economic status performa before the experiment, and physics proficiency test was administered as pretest and post test before and after the experiment. Following null hypothesis were tested by analyzing data collected from four groups.

Table 1: HYPOTHESIS TESTING

Sr. No.	Hypothesis	Methods	Mean	Mean Difference	Difference in SD	df.	t	Sig.
1	**H01:** There is no significant difference of scientific inquiry method of teaching and Lecture method of teaching on students' achievement in physics.	Lecture Method	31.2667	-6.3888	1.28678	29	-27.194	.000
		Scientific Inquiry	37.6556					
2	**H02:** There is no significant difference of guided scientific inquiry method of teaching and Lecture method of teaching on students' achievement in physics.	Lecture Method	31.2667	-9.3666	2.12511	29	-24.142	.000
		Guided Scientific Inquiry	40.6333					
3	**H03:** There is no significant difference of unguided scientific inquiry method of teaching and Lecture method of teaching on students' achievement in physics.	Lecture Method	31.2667	-3.30000	.87691	29	-20.612	.000
		Unguided Scientific Inquiry	34.5667					

4	**H04:** There is no significant difference of combine scientific inquiry method of teaching and Lecture method of teaching on students' achievement in physics.	Lecture Method Combination Scientific Inquiry	31.2667 37.7667	-6.50000	2.88576	29	-12.337	.000
5	**H05:** There is no significant difference of guided scientific inquiry method of teaching and Lecture method of teaching on students' ability to apply knowledge of physics concepts in real life.	Lecture Method Guided Scientific Inquiry	8.5000 11.8000	-3.30000	.95231	29	-18.980	.000
6	**H06:** There is no significant difference of unguided scientific inquiry method of teaching and Lecture method of teaching on students' ability to apply knowledge of physics concepts in real life.	Lecture Method unguided Scientific Inquiry	8.5000 9.0000	-.50000	.57235	29	-4.785	.000
7	**H07:** There is no significant difference of combined scientific inquiry method of teaching and Lecture method of teaching on students' ability to apply knowledge of physics concepts in real life.	Lecture Method Combination Scientific Inquiry	8.5000 10.6667	-2.16667	.64772	29	-18.322	.000
8	**H08:** There is no significant difference of combined scientific inquiry method of teaching and guided scientific inquiry method of teaching on students' achievement in physics.	Combination Scientific Inquiry Guided Scientific Inquiry	8.5000 9.0000	-.50010	.57240	29	-4.782	.000
9	**H09:** There is no significant difference of combined scientific inquiry method of teaching and unguided scientific inquiry method of teaching on students' achievement in physics.	Combination Scientific Inquiry Unguided Scientific Inquiry	10.6667 8.5000	-3.30000	.95230	29	-18.981	.000
10	**H010:** There is no significant difference of guided scientific inquiry method of teaching and unguided scientific inquiry method of teaching on students' achievement in physics.	Unguided Scientific Inquiry Guided Scientific Inquiry	8.5000 10.6667	-3.41212	.96230	29	-17.981	.000

Table 1 show that all null hypotheses were rejected. Therefore

- There is significant difference of scientific inquiry method of teaching and Lecture method of teaching on students' achievement in physics. Scientific inquiry method of teaching is significantly better than lecture method.
- There is significant difference of guided scientific inquiry method of teaching and Lecture method of teaching on students' achievement in physics. Guided scientific inquiry method of teaching is significantly better than lecture method.
- There is significant difference of unguided scientific inquiry method of teaching and Lecture method of teaching on students' achievement in physics. Unguided scientific inquiry method of teaching is significantly better than lecture method.

- There is significant difference of combine scientific inquiry method of teaching and Lecture method of teaching on students' achievement in physics. Combination scientific inquiry method of teaching is significantly better than lecture method.
- There is significant difference of guided scientific inquiry method of teaching and Lecture method of teaching on students' ability to apply knowledge of physics concepts in real life. Guided scientific inquiry method of teaching is significantly better than lecture method.
- There is significant difference of unguided scientific inquiry method of teaching and Lecture method of teaching on students' ability to apply knowledge of physics concepts in real life. Unguided scientific inquiry method of teaching is significantly better than lecture method.
- There is significant difference of combined scientific inquiry method of teaching and Lecture method of teaching on students' ability to apply knowledge of physics concepts in real life. Combination scientific inquiry method of teaching is significantly better than lecture method.
- There is no significant difference of combined scientific inquiry method of teaching and guided scientific inquiry method of teaching on students' achievement in physics.
- There is no significant difference of combined scientific inquiry method of teaching and unguided scientific inquiry method of teaching on students' achievement in physics.
- There is no significant difference of guided scientific inquiry method of teaching and unguided scientific inquiry method of teaching on students' achievement in physics.

6. DISCUSSION

The differences between the means scores on the physics proficiency test by experimental groups were highly significant and statistically in favour of scientific inquiry. This proved that scientific inquiry is better method of teaching for teaching physics at secondary level. Mean scores of guided scientific inquiry (40.6), unguided scientific inquiry (31.6) and combination scientific inquiry (37.8) were compared with lecture method (34.3). The results of the research indicated that guided scientific inquiry, combination scientific inquiry, and unguided scientific inquiry methods of teaching physics are respectively better than lecture method. In the comparison of guided scientific inquiry, combination scientific inquiry, and unguided scientific inquiry methods it is also found unguided scientific inquiry, combination scientific inquiry, and guided scientific inquiry methods are respectively better methods for teaching physics. These results also supported by the R. M, Goertzen. (2000) research findings on teaching physics by inquiry.

This research also signified that the students who taught by the guided, unguided and combination scientific inquiry methods of teaching were better in applying the concepts of physics to real life situations as compared to those students who were taught with traditional lecture method of teaching physics. So it means that the results were highly significant statistically in favour of guided scientific inquiry, unguided scientific inquiry and combination scientific inquiry. All the findings of this research were supported by the research work of Sweller's (1988, 1999) supported guided inquiry. Jabot, Michael and Kautz, Christian (2000) compared two different methodological approaches to the teaching of heat and temperature.

7. CONCLUSIONS AND RECOMMENDATIONS

According to Hrepic, Zollman & Rebello (2007) lecture is probably the oldest instructional format and today it is still the most common form of instruction. A study by Doucet et al (1998) reported that in the lecture format learners are passive recipients of knowledge in an externally driven process. Traditional lecture method of teaching is teacher centered and students are passive listeners only, where as in modern methods of teaching students are involved in all activities, organized and supervised by the teacher. Peek, Winking and Peek (1995) state that the traditional lecture technique is preferred by many lecturers because it may be perceived as a strategy for establishing and maintaining order in the class and serves as safety net for new teachers who may be unfamiliar with using other methods. The traditional lecture is a more effective way of teaching when a large quantity of information is to be disseminated Miller (2003) and Peek et al (1995). The development of appropriate teaching material for use in the traditional lecture format (Cardoso et al (2009)) could have helped the teacher keep the attention of students. One important difference between a victorious teacher and ineffective teacher is the methods and materials they use in creating interest of their students in their subject. Powell and Kalina (2009) report that the social constructivist theory, involving individual and cognitive constructivism, is a highly effective method of teaching which all students can benefit from since collaboration and social interaction are incorporated.

In the social constructivist classroom there are different approaches such as inquiry, discussion, problem solving, conversation, debate, and cooperative learning. It may be concluded that guided, unguided, and combination scientific inquiry method of teaching is significantly better than traditional lecture method of teaching for the subject of physics. The following recommendations seem to be reasonable and approachable:

- The research indicated that scientific inquiry method of teaching for the subject of physics is statistically significant than lecture method for teaching physics. It is therefore recommended that teacher education programs may emphasize inquiry teaching method and in-service teachers should be provided training or refresher course to enable them to use scientific inquiry teaching methods in classroom.
- This research may be replicate for other science and arts subjects.
- This study may be replicate by including gender variable.
- This study may be replicate by including location variable
- More Researches are recommended to compare demonstrate and scientific inquiry methods of teaching physics.
- Seminars and conferences may also be organized to disseminate the findings of this research.

8. References

Afzaal, M and Christie, T. (2005).Rote Memorization as a Sufficient Explanation of Secondary School examination Achievement in Pakistan: An Empirical Investigation of a Wide Spread Assumption Retrieved April 8, 2006 from http://www.aku.edu?AKUEB?pdfs/IAEA05.pdf

Anderson, Ronald D. (2007). Inquiry as an Organising Theme for Science Curricula.Abell, Sandra.K. & Lederman, Norman G. (Eds.), Handbook of research on Science Education (pp807-830).London. Lawrence Erlbaum Associates, Inc.

Beth, Warren, Puttick, Gillian M, Conant, Faith & Rosebery, Ann S. (1992). Sense making Practices in Science: Case study of an ESL Teacher. Retrieved August 7, 2006, from http://www.exploratorium.edu/IFI/resources/workshops/sense making.html

Budnitz, Norman. (2000).What do we mean by inquiry? Retrieved March 23, 2006, from http://www.biology.duke.edu/cibl/inquiry/what_is_inquiry.htm.

Burnside, Michael .Eric. (2002) Physics Education Research: Summation and Application Retrieved October 2, 2007, from http://physics.ucsc.edu/~josh /burnside/

C.H. Kautz, P.R.L. Heron, M.E. Loverude, and L.C. McDermott, (2005). "Student understanding of the ideal gas law, Part I: A macroscopic perspective," Am. J. Phys. 73 (11) 1055-1063

C.H. Kautz, P.R.L. Heron, P.S. Shaffer, and L.C. McDermott, (2005). "Student understanding of the ideal gas law, Part II: A microscopic perspective," Am. J. Phys. 73 (11) 1064-1071

Committee on Development of an Addendum to the National Science Education Standards on Scientific Inquiry, Center For Science, Mathematics, and Engineering Education, National Research Council .(2000).Retrieved August 25,2005,from http://books.nap.edu/html/inquiry_addendum/index.htm

D.L. Messina, L.S. DeWater, and M.R. Stetzer, (2004). "Helping preservice teachers implement and assess research-based instruction in K-12 classrooms," in Proceedings of the 2004 Physics Education Research Conference, Sacramento CA, August 2004, edited by J. Marx, S. Franklin, and P.R.L. Heron, AIP Conference Proceedings.

Definition: teaching (n.d.). Webster's revised unabridged Dictionary. Retrieved March 15, 2007, from http://dictionary .die.net/ teaching

Dictionary of the English Language. (2003). Teaching. Retrieved May 07, 2008, from http://www.thefreedictionary.com/teaching

Dyasi, H. (2006). What Children Gain by Learning through Inquiry. Foundations V.2. Retrieved on 26-12-2006. from http://www.exploratorium.edu/tfi.

Education. (2008). In Merriam-Webster Online Dictionary. Retrieved June 25, 2008, from http://www.merriam-webster.com/dictionary/education

Educational Broad Casting Corporation. (2004). Inquiry Based Learning. Retrieved May 7, 2007, from http://www.thirteen.org/edonline/concept2class/inquiry/

Edwards, Clifford H. (1997). Promoting Student Inquiry. Retrieved December 25, 2007, from http://www.classtech2000.com/toucan/inquiry/inqtotalmod.htm

Exline, Joe (2003).Science as Inquiry: Operational Definition Advancing Science As Inquiry. Retrieved October 6, 2004, from http://www.inquiryscience.com/ documents/definition.htm

Exline, Joe. (2004).Concept to Classroom. Retrieved November 6, 2004, from http://www. thirteen.org/edonline/concept2class./inquiry/index.html

Gagne, R. (1985). The Conditions of learning (4th ed). New York: Holt, Reinhart and Winston.

Gupta, Rajender. (2001). Effective Teaching: Aspects and Techniques. Retrieved January 7, 2006, from http://www.newcastle.edu.au/service/teachinglearning/ teachingreview/gupta1.html

Hansen, Lisa Martin. (2002).Defining Inquiry. Exploring the many types of inquiry in the science classroom. Retrieved November 24, 2004, from http://www.emeraldinsight.com/Insight/manulDocumentRequest.do?hdAction=ref_document_request&r_contentId=0&r_atitle=Defining%20inquiry&r_jtitle=The%20Science%20Teacher&r_issn=&r_year=2002&r_volume=69&r_issue=2&r_startpage=34-7&r_endpage=&r_publisher=&r_authors=Martin-Hansen,%20L.

Hartman, Hope. J. (2001).Metacognition In Science Teaching and Learning. Retrieved March 23, 2008, from http://condor.admin.ccny.cuny.edu /~hhartman/mtscitchghtml

Hasnain, Aziz Fatima. (2004). Physics Education in Pakistan .Retrieved March 23, 2008, from http://www.aps.org/units/fed/newsletters/fall2004/pakistan.html

Haury, David L. (2001). Teaching Science through Inquiry with Archived Data. ERIC Digest. (ERIC Identifier: ED465545) Retrieved April 23, 2004, from http://www.ericfacility.net/ericdigests/ed465545.html

Hodson, D. (2007) Towards Scientific Literacy : A Teachers' Guide To The History, Philosophy And Sociology Of Science, Rotterdam : Sense Publishers.

Huber, Richard. A and Moore, Christopher J. (2001).Internet tools for facilitating Scientific Inquiry. Retrieved March 23, 2008, from http://www.ncsu.edu/meridian /001/i win2nternet/internet 2.htm

Hutchings, B. (2006). Principles of Enquiry-Based Learning. Centre for Excellence in Enquiry-Based Learning.

Hyman, Ronald .T. (1970). Ways of Teaching. New York: J.B. Lippincott Company.

Jabot, Michael and Kautz, Christian. (2000). Physics Education Research Conference: The effectiveness of guided inquiry for the teaching of heat and temperature at the high-school level. Abstract Retrieved from March 2, 2007, from http://www.sci.ccny.cuny.edu/~rstein/percabst.htm

Jacobsen, David, Eggen, Paual & Kauchak, Donald. (1989). Methods for teaching .A Skill Approach Columbus: Merrill Publishing Company.

Jakes, David, Pennington and Knodle, Howard. (2002).Using the Internet to Promote Inquiry based Learning. Retrieved January 02, 2006, from http://www.biopoint.com/inquiry/ibr.html

Joshi, S. R. (2005). Teaching of Science. New Delhi: A.P.H. Publishing Corporation.

Kahn, P. and O"Rourke, K. (2005). Understanding Enquiry-based Learning (EBL). In: T. Barret, I. Labhrainn, and H. Fallon (Eds), Handbook of Enquiry and Problem-based Learning. Irish Case Studies and International Perspectives. Galway: CELT.

Kamal, Arif. (2003).The Training of a Physicist: From Concept Building To Problem-Solving Skills. Retrieved May 15, 2004, from http://ngds.ku.edu.pk/kamal

Kamal, Arif. (2004). Conference Papers. Retrieved May 15, 2004, from http://ngds-ku.org/pub/confabst.htm

Kanli, U. (2003). The Efficacy of the 7E Learning Cycle Model Based on Laboratory Approach on Development of Students' Science Process Skills. Gazi University, Institute of Educational Sciences. Retrieved on 12.3.2008. http://www.gefad.gazi.edu.tr/window

Kirschner, Paul, Sweller, John and Clark, Richard E. (2004).Why Unguided Learning Does Not Work: An Analysis of the Failure of Discovery Learning, Problem – Based Learning, Experiential Learning and Inquiry –Based Learning. Retrieved October 17, 2005 from http://projects.ict.usc.edu/itw/materials/clarks/DiscoveryAndProblem_based_learning.pdf

L.C. McDermott, Guest Editorial, (2006), "Preparing K-12 teachers in physics: Insights from history, experience, and research," Am. J. Phys. 74 (9) 758-762.

L.C. McDermott, P.R.L. Heron, and P.S. Shaffer, (2005). "Physics by Inquiry: A research-based approach to preparing K-12 teachers of physics and physical science," APS Forum on Education Newsletter, Summer 2005, pp. 23-26.

L.C. McDermott, P.R.L. Heron, and P.S. Shaffer, (2005). "Preparing K-12 teachers to teach physics and physical science," APS Forum on Education Newsletter, Summer 2005, pp. 19-22.

L.C. McDermott, P.R.L. Heron, P.S. Shaffer, and M.R. Stetzer, (2006)., "Improving the preparation of K-12 teachers through physics education research," Am. J. Phys. 74 (9) 763-767

L.G. Ortiz, P.R.L. Heron, and P.S. Shaffer, (2005). "Investigating student understanding of static equilibrium and accounting for balancing," Am. J. Phys. 73 (6) 545-553

Landis, Carol. (1996). Teaching Science in the Field. ERIC Digest. (ERIC Identifier: ED402154) Retrieved October 25, 2004 from http://www.ericfacility.net/eric digests/ed402154.html

Lederman, Norman. G. (1998). The State of Science Education: subject Matter without Context. Electronic Journal of Science Education V3 N2 Retrieved March 28, 2004, from http://unr.edu/homepage/jcannon/ejse/lederman.html

Lenaerts, J. & Zele., E. Van. (2004). Testing Science and Engineering Students: The Force Concept Inventory. Retrieved March 24, 2007, from http://cripe03.rug.ac.be/publicaties/physicalia2.htm

M.J. Cochran and P.R.L. Heron, (2006). "Development and assessment of research-based tutorials on heat engines and the second law of thermodynamics," Am. J. Phys. 74 (8) 734-741.

McDermott, Lillan. (1998). Students Conceptions and Problem Solving in Mechanics. Retrieved December 7, 2007, from http://www.physics.ohiostate. edu/~jossem/ICPE /C1.html.

Morino Institute. (2003). An Introduction to inquiry based learning. Retrieved January 4,2008, from http://www.youthlearnorg/learning/approach/inquiry.asp

Nayak, A. N. (2004) Teaching of Physics. New Delhi. A .P. H. Publishing Corporation.

P.R.L. Heron and D.E. Meltzer, Guest Editorial, (2005). "Future of physics education research: Intellectual challenges and practical concerns,"Am. J. Phys. 73 (5) 390-394

P.R.L. Heron, P.S. Shaffer, and L.C. McDermott, (2005). "Research as a Guide to Improving Student Learning: An Example from Introductory Physics," Invention and Impact, Proceedings of a Course, Curriculum, and Laboratory Improvement Conference, April 2004, Washington DC, (AAAS, 2005).

P.S. Shaffer and L.C. McDermott, (2005). "A research-based approach to improving student understanding of kinematical concepts," Am. J. Phys. 73 (10) 921-931

R. M, Goertzen. (2000). Physics by Inquiry: Teaching Physics More Effectively. Retrieved January2, 2008, from http://int.phys.washington.edu/~int_talk/REU/ 2002/People/Goertzen_RM/ht/02.html

Rames, James. (2004).Quotations on Teaching, Learning and Education. Retrieved May, 7, 2008, from http://www.ntlf.com/html/lib/quotes.htm

Rao, Aman. (1993).Teaching of Physics. New Delhi: Anmol Publications

Rashid, Khalid. (2004). Education. Lahore: Caravan Book House.

Rashid, Khalid. (2005). Physics in different cultures. Retrieved May 15, 2005, from .http://wwwkfunigraz.ac.at/exp8www/wyp2005/w8-report.doc

Sadker, Myra Pollack & Sadker, David Miller. (2003) Teachers, Schools, and Society Mc Graw Hill.

Salih, A. (2004). The effects of inquiry-based instruction on the development of integrated science process skills in Trainee primary school teachers with different piagetian developmental levels. Gazi Egitim Fakultesi Dergisi, 24(3):275-290.

Saskatchewan. (2000).Chapter 1: The Foundations for Refining Instructional Practice .Retrieved March 2, 2008, from http://www.sasked.gov.sk.ca/doc/pol cy/approach/instrapp02.html

Second International Symposium on issues in higher Education in Pakistan. (2006). Retrieved March 2, 2008, from http://www.pepfoundation.org/symposium2_index.html

Secondary Education. Encyclopedia Wikipedia. (2008).Retrieved February 2, 2008, from http://en.wikipedia.org/wiki/Secondary_education

Sola, A.O. and Ojo, O.E. (2007). Effects of project, inquiry and lecture-demonstration teaching methods on senior secondary students' achievement in separation of mixtures practical test. Educational Res. and Review 2(6): 124-132 ISSN 1990-3839, Retriev.

Standard Department British Colombia. (1999).Retrieved December 2, 2007, from http://www.bced.gov.bc.ca/irp/physics/phprog.htm

Tresise, Jenny, Muir, David, McMahon, Douglas & Barr, Richard.J. (1972). Teacher's Guide to Physics is Fun. London: Heinemann Educational Books Ltd.

USAID.(2008).Education. Retrieved April 29, 2008 from http://www.usaid.gov/ pk/education/index.htm

Wahiduddin Khan, Maulana. (1998). Importance of Education. Retrieved May 15, 2005, from http://www.alrisala.org/Articles/tazkiya /education.htm