

Effectiveness of Inquiry-Based Method for Teaching Mathematics at the Secondary Level

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Abstract

Mathematics is considered as an important subject which is taught up to the secondary level as a compulsory subject. Students' achievements are influenced by the attitude they have for Mathematics subject and the attitude towards Mathematics is affected by teachers and the teaching methods adopted by the teachers. The aim of the study was to find out the effectiveness of the inquiry-based method for Mathematics instruction at the secondary level. The research sample was 30 students studying at secondary level in district Attock. Pretest posttest control group design was used for this research study. Experimental and control group were formed equally on the basis of pretest achievements. Both groups were taught for two weeks. The experimental group was treated with an inquiry-based method using the 5-E model while the control group was treated by the traditional method. After treatment posttest was held and results were compared. Results revealed that the inquiry-based method was better than the traditional method.

Key Words

Effectiveness, Inquiry Based Method, Instruction, Traditional Method

Introduction

One key goal of education is to raise the complete development of a person to change him with a socially desired behavior. It is clear means by which learners are aided to get diverse skills, standards, outlooks, rises and awareness (Edinyang, 2001). It can be possible through active teaching. Teaching methodology plays a vital role in the learning process. The methodology makes sure the conceptual strengthen in the learners' mind. It is a well-planned and logical determination of a tutor for instituting structure in the numerous parts of teaching. The students can learn only by the methodology which the teacher uses during the teaching.

According to World Bank (2013), in the education of school, the base of success is specifically secondary level education in every type of education as it is where learners can either get it or lose it. Mathematics is considered as an important subject which is taught up to the secondary level as an obligatory subject, so Mathematics is taught from the very early stage. The subject of Mathematics is linked to other subjects of science like Physics, Chemistry and other disciplines as well. Gall and Hicks (1964) stated that Mathematics has its valuable role in science and technology, business, agriculture and in other fields as well. The subject of mathematics is concerned with better conception. For better conception, the better teaching method is necessary. Various studies conducted in Pakistan depict that Mathematics is not taught according to the demand of its nature. Mostly it is taught in the traditional method where content-based knowledge is given. (Amirali and Halai, 2010; Tayyaba, 2010). While in neighboring countries like Japan, China and Singapore Mathematics is taught in a problem-solving way using the extrinsic and intrinsic motivation of students (Tu and Shen, 2010). So students' achievements in Mathematics are remained mostly low.

Moreover, students' achievements are influenced by the attitude they have for Mathematics subject. And the attitude towards Mathematics is affected by teachers and the teaching methods adopted by the teachers. Low achievement in the subject of Mathematics is a key concern in developing countries in general and especially in Pakistan (Hoodbhoy, 2007; SPDC, 2003). Horn, (2004) said that it is also an admitted fact that most of the students in Pakistan left out Mathematics at a higher level due to their thinking about Mathematics as a hard, dry and boring subject.

Consequently, they think of themselves as slack for Mathematics. They think that Mathematics needs natural ability. The significance of Mathematics cannot be overlooked in the developing country like Pakistan. It is now the gateway to scientific inventions. So the low achievements of pupils in Mathematics are genuine distress for the nation of Pakistan (Hoodbhoy, 2007; SPDC, 2003)

Many methods are adapted for teaching of Mathematics, some are teacher-centered and some are learners centered. One of them is inquiry-based method which is considered as learner-centered. Inquiry is well-defined as looking for reality or knowledge, exploring information by inquiring." Persons continue the route of inquiry by birth time until they die. The inquiry procedure includes posing questions, observations of existing ideals, collecting facts, and making justifications (National Research Council, 1996). This is a new style in the instruction process established by Dewey. Dewey (1938) explained that inquiry is based on the philosophy of discovery of facts by collecting information from observation, condition and gaining knowledge awareness, through these facts. Unluckily, our traditional educational system has functioned so that it discourages the natural method of inquiry.

As stated by Nazir (2003), mostly lecture method is used in our education system, and there is only one active person i.e. teacher, the role of learners remain passive, as the only listen and receive which teacher communicates. It is not quite sure to what extent the learners accept that information given by the teacher. He further stated that the UNESCO report in 1971, according to this, the lecture method is commonly used in almost every Asian country including Pakistan.

Vosniadou, (2002) stated that, at secondary level, students must be capable to diagnose questions and concepts; design and make scientific investigations; utilization of tools and Mathematics to advance infrastructures and inquiries; modify logical explanations and using justification and confirmation; be aware with and review additional information and models; and link and secure a logical argument. Inquiry-based learning provides openings for learners to get experience through which they can gather knowledge about the humankind. This includes a raised level of communication among learners, educators, and the learning content.

According to Llewellyn (2005), student gets opportunities to explore by him/herself the solutions of the definite problems through inquiry procedure. He/she may use skills with prior knowledge to search and acquire innovative information. The general design of inquiry is as under:

- Posing a question or series of questions
- Discussion is made to recognize the problem and maybe students may able to solve the problem.
- The teacher may guide the learners in the mode of inquiry so that they can gather data.
- The students sum up their information for reaching some desired solution.
- New questions are caused by new difficulties which need new inquiry which makes new conclusions. So the process is completed again.

If students are not enjoying the lesson, it is really hard to take their attention. So the teacher needs to switch on their focus on engaging the students by using the interactive approaches in which student feels more independent. The learners feel more sovereign and resourceful when they are set free to take over the task. By letting learners take over, they guide their learning themselves (Stearns, 2017).

Instructional strategies that teachers use in the teaching of science have significant effects on the students' achievement. Inquiry teaching method facilitates effective learning of separation techniques. Learners that were taught science concepts through inquiry-based teaching method engaged the learned concepts improved than that instruction made through the traditional method. The instructional strategies used by the teachers have a great impact on learner's achievements. In this regard, inquiry-based teaching facilitates effective learning for students (Ibrahim, et al. 2018).

Furthermore, according to Murdoch, (2012), by applying the inquiry-based instruction model, learners not only acquire valuable information, but they also develop a variety of convenient skills around intellect, analysis, and exploration. Furthermore, with a focus on cooperative group effort, students get the chance to create vital soft skills, for instance, communication, problem-solving and team-building. Education consultant, Murdoch, (2012) stated that the inquiry-based method facilitates the thinking process. After long academic research and practical experience, Murdoch formed a useful set of considerations to be followed by the teachers to integrate inquiry into their classroom practices.

- Structure inquiry about challenging, vital questions in spite of closed 'themes'
- Make sure that the selection of content gives you a point to think upon.
- Inquiries should be designed relevant to real-life settings
- Try to produce a type of thinking students mostly use to think.
- Reflect the thinking outlooks that you can 'highlight' though the inquiry
- Motivate students to think about by using the students' own questions.

- Make thinking clear and lead them to reach the solution till the end.

Inquiry-based learning provides openings for learners to get experience through which they can gather knowledge about humankind. This includes a raised level of communication among learners, educators, and learning content. The learner develops strongly concerned in the learning process as (s)he:

- Achieves his/her attention and curiosity.
- Increases questions.
- Reproduce their means through discussions.
- Investigates problems logically.
- Accumulates, explain, and test hypothesis.
- Drafts conclusions and builds plausible resolutions.

As said by Sciuolo (2017), traditional methods of instruction like lectures method and other teacher-centered methodologies, from now on has no effect. Learners need further student-centered methodologies to comprehend and intermingle with the content. Methods like Lectures cannot do much more. Learning hardly occurs in lecture situations as the viewers sit passively in this condition. It really fully failed to capture learner attention any more.

The conclusions were drawn by Khan (2012) that inquiry-based learning students a position to be an active part of the learning process in the Mathematics classroom. But countries like Pakistan, this type of condition was not seen, where students are the passive part of the learning process. The research study exposed that inquiry-based instruction is ignored by teachers and learners inside the classroom; it is also affected by the external classroom factors like curriculum and the evaluation process.

Seyhan and Morgil (2007) compared two groups of students, one taught by the traditional method and other was treated inquiry-based 5-E model. The group treated by inquiry-based instruction was found better than of others.

Purpose of the study

As cited above, in Pakistan mathematics is not taught according to the demand of its nature. Most traditional methods are being used for mathematics instruction. This is a big reason for poor mathematics conception. That's why students show poor results in mathematics. For a better conception of mathematics, experts suggest student-centered method like inquiry based teaching method. So, this study is being conducted to find out the effectiveness of inquiry based method for teaching mathematics.

Hypotheses

Following null hypotheses of study were formed:

1. No substantial change is there among achievements scores of the pre/ post-test of the control group.
2. No substantial change is there among achievements scores of the pre/ post-test of the experimental group.
3. No substantial change is there among scores of both groups on post-test.

Methodology

Pretest posttest control group design was used for research purpose. Thirty students of Govt. High School No.1 Fateh Jang was taken as a sample randomly. The pretest was conducted to find out the achievements. On the achievements of pretest scores, two groups were made equally. The self-developed test was used. The test items were consulted to experts of relevant field for validation. The pilot study was made by selecting ten students from Govt. High School No.2 Fateh Jang. The split-half method was used to find the reliability of the achievement test. For this, the test was divided into two comparable halves i.e. even and odd and then Spear-Brown correlation formula was applied, the value of coefficient was 0.81 which was quite good. Two teachers were selected. They possess the same level of academic qualification and teaching experience. One group was treated by traditional method while another group was given unusual treatment which was inquiry-based 5-E model. At the end of the experiment which continued for two weeks, posttest was conducted of both of the groups. The results of the study were tabulated and analyzed to make the findings. T-test was used to determine the change among means of two groups at a selected probability level in two independent samples.

Findings

Table 1. Analysis of pre-test and post-test of Control Group

Group	Score	Mean Score	\bar{d}	S_d	d	n	t_{cal}	t_{tab}
Pre-test	94	6.27	3.53	1.06	53	15	12.454	1.761

Post-test	147	9.8
<i>d.f = 14</i>		<i>t_{tab} at 0.05 probability level</i>

Table 1 shows that the calculated value of t is 15.63 and it is greater than t-tabulated which is 1.685, so we reject the null hypothesis No.1. Substantial variation was found between scores of the pre-test and post-test of control group achievements. Students' scores are higher taught through the traditional method.

Table 2. Analysis of pretest and posttest of experimental group achievements

group	score	Mean score	\bar{d}	S _d	d	n	t _{cal}	t _{tab}
pre-test	94	6.27						
post-test	158	10.53	4.27	2.02	53	15	7.906	1.761

d.f = 14

t_{tab} at 0.05 probability level

Table 2 shows that the calculated value of t is 7.906 and it is greater than t-tabulated which is 1.761, so we reject the null hypothesis No.2. Substantial variation was found between the pre-test and posttest of experimental group achievements. Students' scores are higher taught through inquiry based E-5 model.

Table 3. Analysis of control group and experimental group on post-test

group	score	Sum of squares of scores	mean	S _d	n	t _{cal}	t _{tab}
Post-test score of experimental group	158	1702	10.53				
Post-test score of control group	147	147	9.8	0.218	30	9.125	1.701

d.f = 28

t_{tab} at 0.05 probability level

Table 3 shows that the calculated value of t is 9.125 and it is greater than t-tabulated which 1.701 is. So we rejected the null hypothesis as Substantial variation was found between scores of the control group and experimental group on post-test. Students' scores are higher taught through inquiry-based E-5 model than of students taught through the traditional method.

Conclusions

The results of the study show that the difference was observed in both of the groups after the treatment. The first null hypothesis was rejected as a substantial difference was recorded between the mean scores of the control group on pre-test and post-test. It shows that student's achievements went up after teaching by traditional method. The null hypothesis No.2 was also rejected as the substantial change was recorded among the mean scores of pre-test and post-test of the experimental group. It shows that student's achievements also improved in this case also. The learning level of students increased after by teaching them with inquiry method model 5-E, The third null hypothesis was also rejected as the Substantial variation existed between the mean scores of the control group and experimental group on post-test which proved experimental group treated by inquiry-based method 5-E model better than of control group treated by traditional method.

Discussion

The results of the current research study show that the group treated through inquiry-based method proves better than others. The results of the study are in line with the study done by Riordan & Noyce in 2001, in which they showed that students instructed by inquiry-based method showed good results. One study was done by Aktamiş, Hiçde and Özden in 2016 determined that inquiry-based teaching associated with the conventional teaching methodology had "lot more positive effects on the assertiveness of the students towards science and mathematics."

As a result of the great level of involvement required from inquiry-based learning, students are plausible to enlarge their content awareness. Such type of outcomes can be observed in research studies conducted in past by Deborah Maxwell, Dawn Lambeth, and J. T. Cox in 2015, in which they found higher scores who were taught by the inquiry-based method. The inquiry-based 5-E model proved better than of the traditional method. The results of the study are same as Pi-Hisa, et. al (2013), Abdi (2014), Sungur, et. al, (2001); Lord, (1999); Seyhan and Morgil, (2007) and Anderson, (2002).

Recommendations

1. Teachers of mathematics may be encouraged to use the inquiry-based 5-E model in their instruction and a training program should be encouraged for helping mathematics teachers to be familiarized with this method.
2. Students' active participation in the learning process may be strengthened by shifting students' passive part to an active part as improved classroom conditions.
3. Students' own questioning be utilized to motivate the mathematics students and this should be encouraged by both the teachers and students to make a better inquiry.

References

- Abdi, A. (2014). The Effect of Inquiry-Based Learning Method on Students' Academic Achievement in Science Course. *Universal journal of educational Research*, 2(1), 37-41.
- Aktamiş, H., Hığde, E., & Özden, B. (2016). Effects of the inquiry-based learning method on students' achievement, science process skills and attitudes towards science: A meta-analysis science. *Journal of Turkish Science Education*, 13(4), 248-261.
- Amirali, M., & Halai, A. (2010). *Teachers' knowledge about the nature of Mathematics: A survey of secondary school teachers in Karachi, Pakistan*. *Bulletin of education and Research*, 32(2), 45-61.
- Anderson, R. (2002). *Reforming Science Teaching: What research says about inquiry*. *Journal of Science Teacher Education*, 13, 1-2.
- Dewey, J. (1938). *Experience and education*. New York, NY: Collier Books.
- Edinyang, S.D. (2001). *The Relative effectiveness of Inquiry and Expository methods of teaching social studies on the academic performance of students in Akwa Ibom State Schools*. An unpublished M.Ed thesis, Faculty of Education, University of Calabar, Calabar.
- Gall, M. & Hicks, W.V. (1964). *Modern Secondary Education American Book Company*, New York, P.184.
- Hoodbhoy, P. (2002). Education Reform in Pakistan – Challenges and Prospects. Paper presented at Pakistan in the 21st century: Vision 2030, Islamabad.
- Horn, I. (2004). 'Why do students drop advanced Mathematics?' *Association of Supervision and Curriculum Development*, 62(3), 61-64.
- Ibrahim, M. S., Hamza, M., Bello, M., Adamu, M. (2018). Effects of Inquiry and Lecture Methods of Teaching on Students' Academic Performance and Retention Ability Among N.C.E 1 Chemistry Students of Federal College of Education, Zaria. *Open Access Journal of Chemistry*, 2(3), 1-8
- Khan, A. W. (2012). *Inquiry-based teaching in Mathematics classroom in a lower secondary school of Karachi, Pakistan*. *International Journal of Academic Research in Progressive Education and Development*, 1(2), 1-7.
- Llewellyn, D. (2002). *Inquire within: Implementing inquiry-based science standards*. Thousand Oaks, CA: Corwin Press.
- Lord, T. R., (1999). *A Comparison Between Traditional and Constructivist Teaching in Environmental Science*. *Journal of Environmental Education*. Vol. 30, No. 3:22-28.
- Maxwell, D. O., Lambeth, D. T., & Cox, J. T. (2015). Effects of using inquiry-based learning on science achievement for fifth-grade students. *Asia-Pacific Forum on Science Learning & Teaching*, 16(1), 106-136.
- Murdoch, K. (2012). 'Inquiry Learning – journeys through the thinking processes', *Education Consultant*, <http://kathmurdoch.com.au/index.php?id=22>
- National Research Council. (1996). *National science education standards: Observe interact, change, learn*. Washington, DC: National Academy Press.
- Nazir, I. (2003). *A Study of Education of Teaching of General Science at Secondary School :Level in Gujjar Khan* (Unpublished; M.A Thesis) International Islamic University Islamabad (Pakistan). P-25.
- Pi-Hsia, W, Yu-Ren, Y, Hui-Ju, W. &, Pai-Lu, W. (2013). *The learning effectiveness of inquiry based Instruction among vocational high school students*. *Educational Research International*. ISSN-L: 2307-3713, ISSN: 2307-3721, Vol. 2 No. 2 October 2013 www.savap.org.pk
- Riordan, J. E., & Noyce, P. E. (2001). The impact of two standards based mathematics curricula on student achievement in Massachusetts. Riordan, J. E., & Noyce, P. E. (2001). The impact of two standards based mathematics. *Journal for Research in Mathematics Education*, 32,368-398.
- Sciullo, N. (2017). The lecture's absent audience. *Communication Education*, 66(2), 237-239.
- Seyhan, H. & Morgil, I.(2007). *The effect of 5E learning model on the teaching of acid-base topic in chemistry education*. *Journal of Science Education*, 8(2), 120-123.
- SPDC. (2003). *Social Development in Pakistan Annual Review 2002-03: The State of Education*. Karachi: Social Policy and Development Centre (SPDC).
- Stearns, S. (2017). What is the place of lecture in student learning today? *Communication Education*, 66(2), 243-245.
- Sungur, S., Tekkaya, C. & Geban, O. (2001). *The contribution of conceptual change texts accompanied by concept mapping to students' understanding of human circulatory system*. *School Science and Mathematics*, 101, 91-101.
- Tayyaba, S. (2010). *Mathematics achievement in middle school level in Pakistan: Findings from the first national assessment*. *International Journal of Educational Management*, 24(3), 221 – 249.

- Tu, R., & Shen, W. (2010). *Fundamental focuses of Chinese Mathematics education: Characteristics of Mathematics teaching in China*. *Journal of Mathematics Education*,3(2), 160-169.
- Vosniadou, S. (2002). *On the nature of naïve physics*. In M. Limon and L. Mason (Eds.), *Reconsidering conceptual change*. Issues in theory and practice. Dordrecht, The Netherlands: Kluwer Academic Publishers.
- World Bank. (2013). Secondary education. Retrieved from: www.worldbank.org/education/secondary