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Using 5e's Instructional Model to Study the Concept of Magnetic Hysteresis Curve in Physics

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Abstract

Using a learning cycle approach namely 5E's Instructional Model in the classroom or laboratory helps to improve science subject learning at each level because learning cycles work on the constructivist approach. Although there are many kinds of learning cycles, here we use the inquiry-based teaching and learning of the 5E Instructional Model (Bybee & Landes, 1990).

The study explores the effects of 5E Instructional Model on the students' understanding of concepts related to magnetic hysteresis curve or loop. A sample 120 students participating in answering questions on the concept of magnetic hysteresis curve were selected from two higher secondary schools of district Mardan. The nature of the study was experimental in which concept formation method of teaching was compared with traditional method of teaching. An achievement test was arranged. Pretest and posttest were used for the collection of data. Each of the experimental and controlled group was taught with concept formation and traditional method of teaching for six weeks. Pre-test was arranged in the beginning of the experiments. After six weeks post-test is taken in order to know the effectiveness of concept formation method and traditional method.

After analyzing the response of the students, most of the students had the alternative conception on the concepts related to magnetic hysteresis curve as given in part first before the treatment. But in part second after the treatment, maximum number of students achieved the scientific understanding of the magnetic hysteresis curve or loop while some of the students still had their previous or traditional conceptions. Hence the results of the study indicated that concept formation methodology of teaching was more effective as compared to traditional method.

Keywords: 5E's, magnetic hysteresis curve, Concept formation, traditional approach, K-12 students.

Introduction

Science education actually describes and explains the ability of students to identify scientific issues, explains scientific phenomenon using scientific evidence and observation, deduces, analyses, solves and makes decisions about all the life situations involving science and technology, "such that an individual in order to participate fully in today's global economy, needs to be able to solve scientific ideas, scientific experiment, clearly and persuasively" (OECD, 2007, p. 33).

According to PISA 2015, scientific literacy is divided into three domains. First domain is the ability of an individual to study and explain a natural and technological phenomenon scientifically and evaluating explanations for these phenomena. Second one is to study and design a scientific enquiry that is evaluating and finding scientific investigations and raises questions scientifically on the understudy phenomenon. The third and last domain is to study and construct the data and all suggestions scientifically, that is, analyzing and evaluating data and then deriving appropriate scientific results (OECD, 2013, p. 7).

According to DeBoer (1991, p. 240), science education produces in an individual independence, self-activity, question creativity, and empowers the ability in an individual to think and to act, observe and create new ideas, to produce the investigative skills that contribute to self-regulation, self-esteem, personal satisfaction, and social responsibility in a society, interconnected experimental and theoretical knowledge, and the internal ability and skills due to which an individual works with what is known, and cognizance of the contexts due to which that knowledge and those skills apply.

To develop the science education, the National Science Foundation stressed that science education should be given more emphasis as compared to other subjects and rethought with more interest. According to it more and more concentration and emphasize may be given on science and technology education (Hurd, 1998, p. 409).

To enhance science education there is an approach of "Science for All". This approach stresses that there is a need that all students should be scientifically literate for a socially sound society. So, this approach is important for an individual or society to adopt science education so that they will face the future challenges and issues. (DeBoer, 1991, p. 174).

According to European Commission, scientific literacy provided by science education does not mean that each and every one is expert in science education and literacy. But it is important and necessary to know about their environment. Knowledge of science is important for a human being personality, social, moral, and well professional life. Thus, the role of scientific literacy is central to prepare a young person for life. (OECD, 2013, p. 28).

Thus, science education has a great contribution in society and also in the reflective approach to science as well. Scientific literacy is the main purpose and achievement of science education and this helps students worldwide. So, science education is a major part of the curriculum for the purpose of enhancing scientific literacy (American Association for the Advancement of Science, 1993. p. 323).

Inquiry and the Learning Cycle

Inquiry based learning is actually the construction or discovering of information about an evidence, experiment, or scientific inquiry. It encourages and motivates students in the field of learning instead of teachers directly lecturing or suggesting the information about the topic (Uno, 1999).

Before 1900, most of the educators and instructors viewed that science education meant students learning through memorization, reading, and through direct instruction. But this concept is not followed now. By the 1950's and 60's, an inquiry-based learning became more and more visible and applicable (National Research Council, 2000).

However, the shift from textbook and memorization in a classroom to hands-on approach is more result-oriented and the student-centered not the teacher-centered. Teacher is only a guide. Recent research findings showed that inquiry-based learning approach is beneficial to students to learn more as compared to memorization in the classroom (Etheredge & Rudnitsky, 2003).

According to the National Research Council (2000) "Inquiry based learning in a classroom in which students use scientific inquiry and experiments to learn is most effective learning for understanding as compared to traditional classroom" (p. 124).

A learning cycle model consistent with modern theories about how individuals learn, new experiments used for a scientific phenomenon, constructivist ideas of the nature of science, data collection and conclusions, and the developmental theory of Jean Piaget (Piaget, 1970).

The transfer and application of inquiry-based learning in the classroom or laboratory can be developed by using experiments, practical tools for explanation of the research activity. So, the most popular and result oriented strategy is that which can be helpful to teachers and instructor, as the use of the development of inquiry-based lessons which involves the use of a learning cycle approach in the classroom (Abraham, 1997).

Bybee links the goals of science education to society, social ideas, recognition of the socio-historical development, moral values, ethical aspects, cultural dimension, society development, and social responsibility of science. A small group of individual and students had concentrated on science education in schools and colleges; that is, at lower level of education and higher level of education, these groups prepared students and individual future developing with science. (Bybee, 2002, p. 24).

Roger Bybee was the first who developed the 5 E model of learning under the Biological Science Curriculum Study and explain the five level of a research inquiry starting from word E that is **Engage, Explore, Explain, Elaborate**, and **Evaluate**.

Here in this model Science teachers, science instructor and curriculum developers may use and apply the model at several levels of learning. The constructivists' learning model can be used and developed for a sequence of daily lessons in schools and colleges, individual units, monthly plans, or yearly plans (Bybee, 1997).

5E Instructional Model

The lessons in this 5Es model promote active learning in students in a classroom. Students are involved practically in the activity as compared to listening and reading an activity. They are developing skills experimentally and practically, analyzing their practical work, and evaluating evidence, experiencing and discussing with other students, and talking to their teachers about their own understanding. To solve problems, students work collaboratively with other students and plan investigations. Research shows that students find it better to learn when they work with others in a collaborative study environment as compared to work alone in a competitive study environment. It is observed and found that, in collaborative learning, students succeed in making their own discoveries and experiment. Here students ask questions about the scientific inquiry, observe, analyze, explain, and also draw results and conclusions. These inquiry-based experiences involve students in direct experimentation and also students develop explanations through critical thinking.

Constructivist view of learning of a scientific inquiry identifies that students need time to

- Express and elaborate their current thinking
- Interact and familiar with scientific apparatus, with objects, substances, and equipment due to which students develop a range of experiences on which their thinking based.
- Comparing their thinking with other students
- In the 5E model of learning students have the opportunity to construct their thinking and understanding of a concept formation over time. This model leads students through five consecutive phases of learning that begin with the letter E: Engage, Explore, Explain, Elaborate, and Evaluate.

The following paragraphs shows with explanation that how the five E’s are implemented across the research activity or scientific inquiry.

- **Engage:** The Engage lesson which is called the first phase of learning cycle provides the opportunity for teachers to find out what students already know or think about the scientific inquiry or topic and about the concepts to be developed. This phase also gives the opportunity to learner to consider what his or her current ideas and thoughts about the topic or scientific thinking. The Engage phase should also capture students’ interest about the topic and concepts learning. Students come to learning situations with previous knowledge. Here the teacher finds the students’ prior knowledge and identify and explain any knowledge gaps. In this phase teachers might task students and encourage students with asking opening questions or writing down something about the topic what they already know about that topic.

Points of Engage Lesson are Given Below;

- Determine students’ current understanding about subject given that is magnetic hysteresis loop.
- Motivate students to raise and discuss their own questions about the process of scientific inquiry.
- Encourage students to compare their ideas with those of others’ work done on same subject.
- Create interest and stimulate curiosity in the scientific inquiry in the subject of experiment.
- Make a connection between past and present learning experiences of the students in activity.

Explore

In this second phase of learning working with questions, students attempt to investigate the nature of scientifically testable questions. Students engage and generate their own set of testable and reasonable questions. This lesson provides a common set of experiences within which students can begin to construct their own understanding and thinking.

Characteristics or Points of Second Lesson *Explore* are Given Below

- Students discussed different ways to solve a problem or frame a question.
- Students gain a common set of experiences so that they can compare results and ideas with others.
- Students here describe, record, compare, and share their ideas and experiences with their classmates.
- Students express their thinking, developing understanding of testable questions and scientific inquiry

- Students explore the new concept and ideas through concrete learning and observing experiences.

Explain

This is a teacher-led phase that explains and helps the students to synthesize new knowledge. Here teachers should ask students to share their learning and concepts with others. Teachers utilize video, lectures, computer software, or other aides to enhance the understanding capacity of the students. Here students developed their conceptual understanding and skills behaviors. For *explanation* in this phase, teachers can use formal terms, definitions, and explanations for concepts formation, processes, skills, or behaviors.

Characteristics or Points of Third Lesson Explain are Given Below

- The *Explain* lesson encourages students and motivates the students to explain concept and idea about experimental topic.
- Teachers must listen to students in revising their ideas and current understanding.
- Teachers use simple words form, use labels, terminology, and formal language.
- Encourage and motivate students to use their common experiences, skills and data from the Engage and Explore lessons to develop explanations.
- Teachers must introduce terminology and alternative simple explanations after students express their ideas

Elaborate

This *Elaborate* phase helps the students to develop a deeper understanding about topic or concept. Teachers may ask students to conduct additional investigations about the topic to reinforce new skills and procedures. This phase allows students to strengthen and reinforce their knowledge before evaluation. In this phase of the 5 E's Model practice skills and behaviors are developed. Through new experiences and scientific inquiry, students obtain more information about areas of interest, and work.

Characteristics or Points of Fourth Lesson *Elaborate* are Given Below

- Connect ideas of students, solve problems, and apply their understanding to a new situation.
- Deepen their understanding of concepts and processes developing.
- Encourage and motivate students to use what they have learned to explain a new idea.
- Encourage students to use scientific terms and descriptions previously introduced
- Ask questions that help students to sketch, draw reasonable conclusions from evidence and data

Evaluate

The Last phase is called the evaluation of what students know and can do, and it is called the summative assessment of the whole scientific inquiry. The 5E Model of inquiry allows for both formal and informal assessment. During this lesson teachers can observe their students and see whether they have a complete hold of the fundamental concepts. The Evaluate phase helps students in self-assessment, peer-assessment, observing, data assessment, writing assignments, and exams. This phase of the 5 E's encourages and motivates the learners to assess their understanding and abilities and here teachers evaluate students' understanding of key concepts of scientific inquiry and skill development.

Characteristics or Points of Fifth Lesson Evaluate are Given Below

- Demonstrate what students understand about a given scientific inquiry and in the light of that knowledge how they investigate and evaluate.
- Share their current thinking with other classmates and friends.
- Observe and record the concepts and skill performance of students.
- Provide time for students to compare their ideas with classmates and perhaps to revise their thinking.
- Interview students for assessing their developing understanding.

Methodology and Procedure

1. To study the concept of magnet hysteresis loop, the procedure or methodology used is quasi-experimental design, that is, pretest and posttest for concept treatment and comparison group. 2. Apply the pretest and posttest on the second year students of physics of two higher secondary schools of district Mardan having 120 (60 and 60 group wise) students. Both secondary school teachers had same degree in teaching physics. Thus, pretest and posttest are used for the concept explanation of magnetic hysteresis loop with ten questions related with magnetic hysteresis loop.

The purpose of both the tests was to study and determine the student's misconception about the concept of magnetic hysteresis loop. Two approaches were applied upon students on the subject. The first approach was the use of cycle learning through 5Es while the second approach was the usual lecture method. Both approaches had same content but completely different in terms of instructional activities.

The 5Es learning cycle were used for experimental group and the lecture method was used for the control group. First, we applied a pretest on both the groups of students to check the physics concept. Then both experimental and control groups were given treatment of the concept of magnetic hysteresis loop using 5Es and lecture method respectively. Both groups were given treatment for a time of 45 minutes, five times in a week for six weeks. The experimental group was taught using 5Es learning model, that is, through engage, explore, explain, elaborate and evaluate. The presentation was done in two parts. In Part I there is student's conception about magnetic hysteresis loop before the instruction began, while part II is conception after the instruction. At the final stage the analysis of subjects was carried out qualitatively.

First part: Concepts of students about magnetic hysteresis loop before treatment
Q.1 Define Magnetic Field.

Experimental group: The region around a current carrying wire or a conductor where its effect can be felt on a testing magnetic materials or substances is called magnetic field.

Control group: Magnetic field is actually a vector field (B) that present the magnetic influence on a region of electric charges in state of motion on magnetized materials

Q.2 Define Magnetic Hysteresis Loop or what do you means by magnetization curve?

Experimental group: When an alternating magnetic field is applied to the material or a conductor, its magnetization will produces a loop called a hysteresis loop.

Control group: The flux density "B" or magnetic induction always lags behind the magnetizing force "H" thus a loop produced called Magnetic hysteresis loop or hysteresis curve.

Q.3 what do you means by magnetic saturation?

Experimental group: Saturation is the state reached when an increase in applied external magnetic field "H" cannot further increase the magnetization of the materials. It is the characteristics of ferromagnetic materials such as iron, nickel and cobalt.

Control group: Saturation is actually a point of diminishing returns at which attempting more externally applied magnetic field (H) will give rise to no additional magnetic induction (B).

Q.4. Define Magnetic Retintivity.

Experimental group: The ability of a materials to retain the generated magnetization when the magnetizing force is removed is called the magnetic resistivity of the given material.

Control group: The power which keep the state of residual magnetism same is called retintivity of the material.

Q.5 Explain Magnetic Coercivity

Experimental group: Coercivity of a material is actually the measure of reverse magnetizing field require to destroy the residual magnetism of the material.

Control group: That values of the magnetizing force which require to wipe out or clear the residual magnetism is called magnetic coercivity.

Q.6 Define Residual Magnetism or Residual flux

Experimental group: The magnetic flux density B which remains in a material when the magnetizing force is zero or removed.

Control group: The value of the flux density B keep by the magnetic material is called residual magnetism.

Q.7 What do you mean by Paramagnetism?

Experimental group: It is a form of magnetism where the material attracted by magnetic field and form internal induced magnetic field along the direction of applied magnetic field.

Control group: When magnetic field is applied to a material such as Aluminum or platinum and become magnetized it temporarily, but when field is removed a magnetic field is.

Q.8 Define Ferromagnetism

Experimental group: A process in which permanent magnetism is produces in some certain materials (such as iron) or are attracted to magnetics.

Control group: Phenomenon possess by the materials like iron (nickel or cobalt) that become magnetized in a magnetic field and retain their magnetism forever when the field is removed.

Q.9 Define Diamagnetism

Experimental group: that process in which materials like copper or bismuth that become magnetized in a magnetic field having a polarity opposite to the magnetic force applied to it. Its property is different as that of ferromagnetism unlike iron they are slightly repelled by a magnet.
Control group: That property of a material has negative magnetic susceptibility means by substances which magnetized in opposite to that of the applied magnetic field. The property of the

material has a magnetic permeability less than 1 and is repelled when placed near a permanent magnet as well.

Second Part: Concepts of students about magnetic hysteresis loop after the treatment

Q.1 Define Magnetic Field

Experimental group: Those atoms having unpaired electrons and having same spin so magnetic field is produces, example is iron, so to make a strong magnetic field iron is used.

Control group: Magnetic field is a vector field B which produces due to different means that is a permanent magnet, electric current, or changing electric field.

Q.2 Define Magnetic Hysteresis Loop or what do you means by magnetization curve

Experimental group: By plotting values of flux density, (B) against the values of field strength, (H) we can achieve a set of curves called magnetization loop or magnetic hysteresis curve or also called commonly B-H curve.

Control group: A magnetization curve or /B-H loop is actually the relationship between the induced magnetic flux density (B) and the magnetization force (H).

Q.3 What do you means by magnetic saturation?

Experimental group: There is a limit at which there is no more sharp increase occur of flux density B in the magnetic substance with more increase of the magnetic field.

Control group: The region beyond which magnetic flux density (B) in a magnetic does not increase further sharply with increase of magnetic field.

Q.4. Define Magnetic Retintivity

Experimental group: The ability of a conducting substance to oppose and resist magnetization, frequently measured as the strength induced field.

Control group: The capacity or the ability of a conducting substance to remain magnetized after he magnetizing field has ceased.

Q.5 Explain magnetic Coercivity

Experimental group: That resistance of a magnetic material which is equivalent to the field intensity necessary to demagnetize the fully magnetized material.

Control group: The magnitude of magnetic intensity decreases to zero the magnetic flux density of a fully magnetized magnetic substance.

Q.6 Define Residual Magnetism or Residual flux

Experimental group: Magnetism left behind in a ferromagnetic conducting substance after the removal of magnetic field.

Control group: When the power is switched off to an electric magnet or a source it will preserves some magnetic power or field behind it, and then the retained magnetic power ability is called residual magnetism.

Q.7 What do you mean by Paramagnetism?

Experimental group: The effect is due to the alignment of unpaired spins of electrons in atoms of the materials.

Control group: When a substance placed in an external the induced magnetic field produces such that direction of applied and induced field are the same ,but when applied field is removed, the materials lose their magnetism that it is not then become a permanent magnet as due to thermal motion randomizes the electron spin and orientation orientations.

Q.8 Define Ferromagnetism

Experimental group: The phenomenon possess by a conducting substances, such as iron, which possess a property of relative permeability greater than one. And due to the application of external magnetic field its induced magnetic field increases, and retain their magnetization when the applied field removed.

Control group: A property possessed by certain conducting materials, below a certain temperature called the Curie temperature, the atomic magnetic moments tend to line up in one direction along the applied field.

Q.9 Define Diamagnetism

Experimental group: It is due to the change in the orbital motion of electrons due to an applied magnetic field. Its magnitude is very weak and small and in reverse direction to the applied field. Its relative permeability is less than 1 and its magnetic susceptibility is negative.

Control group: A materials contain no unpaired electrons not t attracted by a magnetic field Examples wood, water, organic molecules, copper, etc.

Discussion

The study was to examine the effectiveness of Bybee's 5Es learning cycle model on students understanding of the concepts of magnetic hysteresis loop. From the results this study the application of the learning cycle model enhances student's understanding concepts and that of concepts involved in magnetic hysteresis loop.

In 5Es learning cycle model students understand their own hand-on-activities due to the self-involvement in the learning of magnetic hysteresis loop. Due to self-activity, students explored new ideas and materials that encourage them. Students collected data and then analyzed them by testing different concepts about the concept of magnetic hysteresis loop. The students of the experimental group understand from the activities the misconception about the subject due to the self-hand-on-actives and how to correct them. Thus, the 5Es learning cycle model has a teaching methodology in which experimental group of students will have more opportunity to identify, explain, and express their previous-conceptions of understanding and enhance the new concepts and ideas through learning cycle. But in control group total focus were given to learn the subject traditionally.

Frank (1997) finds out that the homework score of the students extremely increases when they performed in experiment related as compared to those students in a control class. Dickie (2004) tested the conceptual effects of seven experiments on the curriculum of Test of Understanding in College Economics by using three classes having 50 students each such that among the classes one of which was a control group class. According to him a significantly larger improvement was found in scores by the experimental group.

Similarly, instruction of qualified teachers affects some concepts and aspects of magnetic hysteresis loop to different degree. So, after instruction students can easily change their views about some points of magnetic hysteresis loop as compare to other students. But in some cases, it is very difficult to change some aspects about the subject, such as those involving the concepts of applied magnetic field and induced magnetic field. So, due to 5Es learning cycle model one can easily understand the difference between them. Thus, this research article showed that the effect of learning cycle model on learning magnetic hysteresis loop was found to be significant on such type of teaching. From the learning and activities of students it was clear that teacher's role of inquiry based teaching is not negotiable in learning science activities or magnetic hysteresis loop. So it is needed that to promote and increase future physics teacher's tendency toward using inquiry based learning are of great importance and due to which they may result in effective physics instruction in each physics activities, and affecting large numbers of future physics learners in schools and colleges.

Conclusion

Based on the application of the two methodologies of pretest and posttest, following conclusions were derived:

- Results of the study suggested that most students possess alternative conceptions of the subject magnetic hysteresis loop concepts.
- Some of the conceptions are dropped by the experimental and control groups after teaching.
- Most students of the control group still had difficulty to change their alternative conceptions.
- It is due to the reason that the physics teachers did not teach through activity wise teaching, due to which the students' alternative ideas in magnetic hysteresis loop was not easy to change.
- When teaching about concepts of magnetic hysteresis loop is through activity based teaching, it provided enough time and opportunity to students to construct their own conceptual model and the properties of magnetic hysteresis loop that were in accordance with scientific conceptions.
- Teachers teaching physics must facilitate conceptual change and become aware of the alternative concept of the subject magnetic hysteresis loop in the classroom.
- The students of the experimental group clearly understand the differentiation between applied magnetic field and induced magnetic field due to self-activity learning.
- The students of controlled group did not differentiate the difference between two magnetic fields after the posttest because due to the lecture or traditional method their concept was not developed.
- Due to concept formation method, students understand the concept of retintivity and coercivity in magnetic hysteresis loop.
- But due to traditional and lecture methodology of teaching controlled groups of students are confused with the terms retintivity and coercivity.
- Due to 5Es learning cycle, most students of the experimental group developed their learning about the concept of magnetic hysteresis loop.
- But due to traditional method, most students learned the definitions terminology but only some students gained the concept about the subject magnetic hysteresis loop.
- The performance of the experimental group of students on the topic concept of magnetic hysteresis loop was better in their posttest than in their pretest.

- The effects of the concept formation method on magnetic hysteresis loop were satisfactory and better for the entire experimental group.
- Students should work together in groups for the purpose to solution of problems, devise strategies and concepts formation.
- Students should predict that up to what extent changing the experiment will change the outcomes.
- Students should compare the experimental results with traditional classroom theories results for promoting science concept about the subject.

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