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A Comparative Study of Science Teaching Through Traditional Method and 5E Models at Secondary Level

Chandana Kumari*

Research Scholar, Department of Education, Brabu Muzaffarpur

Abstract – Two third-grade science courses were examined in this study to see if the 5E Learning Cycle or traditional teaching methods were more effective in enhancing student achievement, interest, and engagement. A three-week 5E Learning Cycle unit and a three-week traditional teaching method unit were completed by both classes. The 5E Learning Cycle units had greater student scores, interest, and engagement than the traditional teaching method components.

Keywords – Science, Traditional, Teaching, Methods

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INTRODUCTION

A flurry of science education reform measures are sweeping the country, merging state and national programmes, high-stakes testing, and funding constraints. The National Science Education Standards (hereafter referred to as The Standards) (National Research Council [NRC], 1996) and Project 2061: Science for All Americans are two major national reform projects aimed at developing scientifically literate people (Rutherford & Alhgren, 1990). According to the Science Teaching Standards, the pedagogical methods used to teach pupils have an impact on what they learn. Project 2061: Science for All Americans, on the other hand, is founded on the belief that a scientifically literate individual is one who understands that science, mathematics, and technology are interdependent human endeavours. According to both reform reports, science teaching should actively engage students, incorporate cooperative learning, and place less emphasis on rote memorization of information. In addition, a common theme running across all reform texts is the incorporation of inquiry-based teaching methods. This research examines a special learning cycle in science classes that promotes curiosity.

Inquiry-Based Teaching

Inquiry is an approach that enables students to uncover or develop information on their own rather than having teachers give it to them directly (Uno, 1999). Inquiry-based learning has been used in science classrooms for less than a century. Prior to 1900, most educators saw science as a collection of facts that pupils were expected to memorise and understand through direct instruction. By the 1950s and 1960s, however, an inquiry-based logic had become increasingly prominent (National Research Council [NRC], 2000). The Standards (NRC, 1996) and Project 2061: Science for All Americans (Rutherford & Alhgren, 1990) believe that inquiry should be a core strategy in all science curriculum.

However, moving to inquiry-based pedagogical practises in the classroom may demand a change away from textbooks as the primary source of science information and toward a more hands-on approach in which students are at the centre of the learning events. Students benefit from an inquiry-based approach, according to recent research findings, and even young infants can learn through inquiry processes (Etheredge & Rudnitsky, 2003). The National Research Council's latest paper (Bransford, Brown, & Cocking, 1999) demonstrates a broad consensus on learning processes. According to the National Research Council (2000), "a classroom in which students employ scientific inquiry to learn is one that matches those that research has revealed to be the most effective for learning for comprehension."

Despite the fact that inquiry-based reform efforts are common across the country, many educators may be unsure of how to create scientific courses that support inquiry learning. Using practical tools or templates for instructional design, however, it is possible to translate and apply inquiry-based approaches in the classroom. The use of a learning cycle method, for example, is one strategy that can be beneficial to teachers when they begin to construct inquiry-based classes (Abraham, 1997). The learning cycle technique has its origins in the Science Curriculum Improvement Study (SCIS), a

1950s elementary school science curriculum initiative (Atkin & Karplus, 1962). A learning cycle model splits instruction into different phases based on a pre-determined planning technique, and is in line with current views about how people learn, constructivist notions about science, and Jean Piaget's developmental theory (Piaget, 1970). Abraham makes a persuasive case for using a learning cycle as an approach for designing inquiry-based scientific lessons (1997). This report summarises the findings of several research studies, including Abraham and Renner (1986), Ivins (1986), McComas III (1992), Raghubir (1979), and Renner, Abraham, and Birnie (1985), and suggests that, when compared to traditional pedagogy, the learning cycle can result in better retention of science concepts, higher science achievement, superior process skills, improved attitudes toward science and science learning, and improved reasoning abilities.

Traditional teaching methods differ substantially from the usage of a learning cycle approach in the classroom. Learning cycles, for example, are based on constructivist principles and emphasise phenomena explanation and study, the use of evidence to support conclusions, and experimental design. Traditional educational approaches, on the other hand, emphasise the development of skills and techniques, the distribution of ready-made material, and previous knowledge of the outcome of an investigation (Abraham, 1997). Although there are various types of learning cycles, the 5E Instructional Model will be featured here as a means to enhance inquiry-based teaching (Bybee & Landes, 1990).

The 5E Instructional Model

The 5E Instructional Model (Bybee & Landes, 1990) is based on cognitive psychology, constructivist learning theory, and best practises in science teaching and can be used to build a science lesson. Figure 1 depicts the learning cycle, which includes the cognitive phases of engage, explore, explain, elaborate, and assess. According to Bybee (1997), "students redefine, rearrange, elaborate, and revise their initial conceptions using this approach through self-reflection and engagement with their peers and their surroundings." Learners analyse things and experiences and internalise their interpretations in the context of their current conceptual understanding" (p. 176). The concept can be integrated or applied at multiple levels by science teachers and curriculum creators. The model might be the pattern that organises a series of daily courses, individual units, or yearly plans (Bybee, 1997). Each phase of the 5E Instructional Learning Cycle is now described, as modified from Bybee.

Engagement

The teacher's goal in this initial phase of the cycle is to assess students' prior knowledge and/or detect any potential misconceptions. This student-centered phase should serve as a motivator for students to want to learn more about the forthcoming topic. Students might come up with their own introductory question or ask themselves, "What do I already know about this subject?" To pique attention or encourage inquiry, use unexpected occurrences, demonstrations, questions, or graphic organisers like KWL charts. Students brainstorm and write what they Know, Want to know, and (finally) Have Learned about a topic using a KWL chart. The KWL chart is used to assess prior knowledge in students and is frequently returned to throughout the class. The educational task has been identified.

This is not the time to lecture, clarify words, provide explanations, or keep track of definitions.

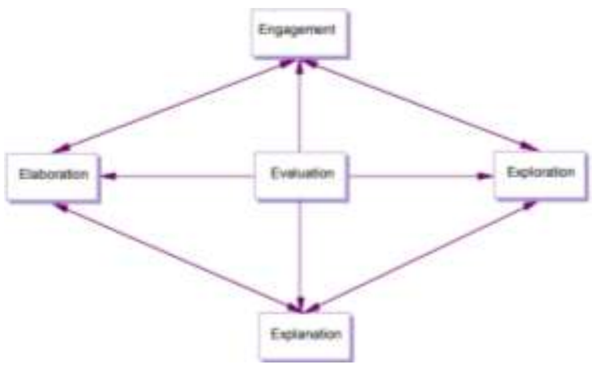

Figure 1: The 5E Instructional Model

Exploration: Following an engagement phase that encourages mental focus on the idea, the exploration phase gives students a shared, real learning experience. This phase is similarly focused on the students and includes active exploration. Students are encouraged to use process skills with other students, such as observing, questioning, exploring, testing predictions, hypothesising, and communicating. The main inquiry-based activity or experience, which helps students to develop skills and concepts, is usually included in this phase of the learning cycle. The job of the teacher is that of a facilitator or consultant. Furthermore, without direct guidance from the teacher, pupils are encouraged to collaborate in a cooperative learning atmosphere. This phase is also unique in that the students are given a "hands-on" experience before the teacher discusses or explains any formal terms, definitions, or concepts.

Explanation: Following the exploration phase, there is a "minds-on" phase that is more teacher-directed and guided by the students' earlier exploration experience. Students can summarise their comprehension and ask questions regarding the subjects they've been learning about during the explanation phase. There is a good chance that new questions may arise. The 5E lesson's explanation phase is a critical, hands-on component. Students must first have the opportunity to offer their own explanations and thoughts before the teacher attempts to supply one. As a result, the teacher's role during the explanation phase is to act as a facilitator, asking students to describe and discuss their exploration learning experiences. The teacher introduces scientific and technical material in a direct manner after the pupils have had the opportunity to express their own explanations. This phase addresses any student misconceptions that may have surfaced during the engagement or exploration phases. There are formal definitions, notes, and labels included. To improve student comprehension, the teacher may choose to incorporate video, computer software programmes, or other visual aids. After that, the students should be able to properly describe the key concepts to both the teacher and their peers.

Elaboration: Students should be encouraged to apply their new grasp of concepts while reinforcing new skills at this phase of the learning cycle. Students are encouraged to ask their peers for clarification or to build new experiments or models based on the new abilities or concepts they have learned. This phase's purpose is to assist in the development of deeper and broader understandings of the concepts. Additional investigations, product development, information and idea sharing, and application of knowledge and abilities to other fields are all options for students. This is a fantastic opportunity to combine science with other subjects. Technology may be used in elaboration activities, like as web-based research or WebQuests.

Evaluation: Inquiry-based assessment differs significantly from standard science assessment. Both formal and informal methods of assessment are acceptable and should be used. Non-traditional kinds of assessment, including as portfolios, performance-based evaluation, concept maps, physical models, and journal logs, may, for example, serve as important proof of student learning. Assessment should be considered as an ongoing process during an inquiry-based class, with teachers observing their students as they apply new concepts and skills and seeking for evidence that the students' thinking has changed or modified. Students may also be given the option of conducting self- or peer-assessment. A summative experience, such as a quiz, test, or writing project, may be included in the evaluation.

Despite the fact that the 5E Model has been taught in sequential order, it is frequently required to step back into the cycle before moving on. For example, before students are ready to go on to the elaboration phase, they may need to rotate through several explore/explain rotations. The teacher may move back and forth inside the Es numerous times, or include another engagement before beginning the elaboration phase. The cycle is incredibly adaptable and dynamic. The lesson or unit may take several days to complete. Each day that science is taught, it is not essential to complete one learning cycle. The paradigm is meant to help with conceptual shift and to make science training more consistent and coherent.

TAPESTRIES have a number of 5E lesson plans created by teachers (n.d.). Duran (2013) also includes a lesson that uses a 5E design to engage students in enquiry, and a shortened version of this lesson is included in Appendix A.

Applications of the 5E Instructional Model

Many science classes in Northwest Ohio have used the 5E instructional planning paradigm as a primary instructional design strategy. It has been a key component of reform-based professional development programmes offered by science educators and scientists at Bowling Green State University and The University of Toledo. This organisation has collaborated with K-12 educators to provide 5E lessons and unit plans that support scientific courses and the Ohio Academic Content Standards for Science.

TAPESTRIES (Toledo Area Partners in Education - Support Teachers as Resources for Improving Elementary Science), a 5-year National Science Foundation-funded project, and Project ASTER (Active Science Teaching Encourages Reform), a 2-year project funded by the Ohio Board of Regents' Improving Teaching Quality Program, are among the grant-funded programmes. Both projects are a collaboration between two major institutions in the Midwest and urban and suburban school districts. Both projects aim to:

1. provide effective and sustained professional development for elementary teachers in science content, pedagogy, and assessment,

2. implement high-quality inquiry-based science curriculum and instruction,

3. align curriculum, classroom practise, and student assessment with district-adopted science courses of study and statewide curriculum models and assessments, and

4. Improve elementary teachers' science content knowledge.

Although the academic year activity varies slightly throughout the projects, all of the teachers share a basic 2-week summer institute experience. The summer institute is meant to inspire teachers to go hands-on with their district's inquiry-based science kits. Each session is led by a team of scientists and scientific educators who use the 5E Models as a framework. Teachers create their own 5E unit plans depending on their students' requirements at the end of the summer institute. Around 1,200 teachers from the participating districts received thorough training in science curriculum, methodology, and student assessment. The Urban Affairs Center at The University of Toledo recently released a report that indicates the favourable effects and impact of the TAPESTRIES programme on student accomplishment. The University of Toledo has a comprehensive copy of the study (n.d.).

PRISM (Partnership for Reform through Inquiry in Science and Mathematics), a new project funded by the National Science Foundation's Graduate Teaching Fellows in K-12 Education Program, is in its first year of implementation at Bowling Green State University. Teams of a cooperating teacher and a natural science or mathematics graduate student are working in four school districts to integrate hands-on inquiry into science and mathematics classes. Over the course of three years, about 25 teams will produce full 5E Model unit plans that span the whole school year.

These programmes' ultimate purpose is to promote student learning by providing ongoing teacher professional development. The programmes were created to help kids become scientifically literate, meaning they can understand and apply science while performing well on high-stakes statewide science tests.

Effectiveness of the 5E Model

The 5E Model is an excellent technique to construct inquiry-based science lessons that promote student learning, according to a qualitative examination of TAPESTRIES and Project ASTER final evaluations and participant notebooks. The following are some examples of teacher answers that support this theme:

When I teach science, I'll be able to use the 5E Model to ensure that I'm developing meaningful, purposeful lessons for my pupils. I value making sure I'm relating to past information [engage], providing relevant, hands-on activities [explore], and assessing specific skills I want the children to develop [evaluate]. (Teacher of TAPESTRIES)

I will be able to test the students' knowledge before the exploration activity begins using the 5E Model, ensuring that their evaluations are appropriate for their academic ability level. (Teacher of TAPESTRIES)

Teachers can tailor lessons to the needs of their students using the 5E planning framework. Educators frequently teach chapters or units in the sequence in which they appear in the book. Children with attention problems, on the other hand, can stay focused with a variety of and adaptable instructional methods. The 5E Model is a method that teachers can use to engage pupils in areas that they may not be interested in or have prior knowledge about. (Teacher for Project ASTER)

Students must be actively engaged in their own learning in order to learn and understand science concepts. They must be guided by their teacher in order to learn new things. Teachers must lead their pupils in the direction of observing/discovering and correcting their own misconceptions. True learning comes through inquiry-based learning. A 5E plan aids in the preparation of lessons for this sort of instruction. (Teacher for Project ASTER)

A follow-up question about their use and implementation of the 5E Model was emailed to 30 participants a year after the initial batch of Project ASTER instructors completed their professional development. The following is an example of teacher responses:

Following the exploration, the class is more confident in their ability to explain; as a result, their problem-solving skills improve, and they become better writers as a result of their increased confidence in their ability to explain more thoroughly. Students that may struggle with reading and writing appear to benefit greatly from the 5E lesson planning, which includes all modes of learning.

I've employed the 5E Model and noticed that after I engage them in the beginning, they're more driven to understand the material. The expand phase allows kids to connect science to other subjects, allowing them to grasp the significance of what they're learning.

Students who are more reserved—or simply uninterested—in offering their ideas and opinions are drawn in by a longer interaction period. Once they've invested something in the class, these pupils are more inclined to stick with it. Exploring scientific applications through hands-on activities allows kids to recognise right away that these topics are important to their lives and may be linked to anything they've noticed or thought about.

Teachers leave the projects with new abilities and increased confidence in their ability to teach life, physical, and earth science in an inquiry-based atmosphere. Teachers also claim that as a result of their involvement in the initiatives, they are more confident in their ability to teach science. This increased self-assurance carries over into the classroom, creating an interesting and dynamic learning environment for students.

It teach science to two third-grade classes at Smith Elementary in Helena, Montana, in my job as a third-grade teacher. Smith Elementary School is one of Helena School District #1's 11 elementary schools, with 36 pupils in the third grade. In the third grade, there are a total of 19 females and 17 guys. Eighty-four percent of the 36 students are Caucasian, seven percent are American Indians, six percent are Asian, and three percent are African Americans (Power Teacher, 2013).

During my first four years of teaching, I spent a lot of time figuring out how to improve student achievement, enthusiasm, and engagement in science. I used nearly solely traditional approaches in my first year of teaching. As a class, we read the textbook and I lectured. After the reading or lecture, the students would complete a worksheet. Then, in the fall of 2009, I was introduced to the 5E Learning Cycle through Science and Inquiry Learning in Classrooms (SILC). For the past three years, I've been teaching science ideas utilising the 5E Learning Cycle and traditional teaching approaches. Both classes receive 90 minutes of science education each week. Students learn via reading textbooks, conducting experiments, attending lectures, filling out worksheets, and exploring resources. Plants and animals, Earth's land, Earth's and Space Cycles, Matter, and Energy and Forces are the key science subjects taught in third grade.

It began adopting 5E lessons in my second year of teaching and have preferred to teach science using this way rather than traditional methods. As a result, the goal of the action research study was to figure out which teaching approach resulted in the maximum level of student success, interest, and involvement.

OBJECTIVE OF THE STUDY

1. Study on the science teaching through traditional method and 5e models at secondary level

2. Study on the Applications of the 5E Instructional Model

RESEARCH METHODOLOGY

The goal of this study was to see if traditional teaching methods or the 5E Learning Cycle helped third grade kids learn more effectively. The study involved students from two third-grade schools and covered two science sections. The number of pupils in both classes was the same (N = 36). Each unit lasted three weeks, with 90 minutes of instruction per week for the pupils. Each class got the chance to study using the 5E Learning Cycle as well as standard teaching methods. While one class used the 5E learning cycle to acquire all of the ideas of soils, the other used traditional teaching methods such as lectures, taking notes, and reading the textbook to learn all of the concepts. I switched the teaching approaches for both groups after the soils unit. Traditional teaching methods were used to teach all of the topics in the characteristics of matter unit to the students that learnt about soil through the 5E Learning Cycle. The 5E Learning Cycle was used to teach the properties of matter to the class that learned about soil ideas using standard teaching methods. The tests and assignments were the same for both classes. I was able to establish which strategy provided a higher retention rate, which method students preferred, and which strategy produced a higher percent of engagement towards the end of the study. The Institutional Review Board at Montana State University granted an exemption for this project's study technique, and compliance for dealing with human subjects was maintained.

Students completed the Soils Test and the Properties of Matter Test to establish a baseline of prior knowledge in both modules (Appendices A & B). Both assessments had several sections, including vocabulary, science ideas and comprehension, and critical thinking. A matter concept map was included in the Properties of Matter Test. They completed the same test at the conclusion of each unit to see how much they had learned and retained. Finding the average of each test question and the overall score was used to examine the data. Then, from the pretest to the posttest, I calculated how much each group had improved. After that, it compared the posttest averages for each class.

It collected students' assignments and journal entries from each class throughout the units. I also observed the classes and recorded my observations in a journal.

Students' levels of interest, student quotes, task difficulty, and overall engagement were among the observations I made.

After that, at the end of each unit, the students completed the Soil Attitude Scale and the Properties of Matter Attitude Scale (Appendices C & D). This allowed the pupils to express their preferences for which strategy they favoured. Several questions on the attitude scales linked to how they felt about the issues presented in the lessons. Students were asked to circle the smiling face if they agreed, the frown face if they disagreed, or the neutral face if they were undecided after each question. I compared the number of positive responses in the class that completed the unit using the 5E Learning Cycle to the number of positive responses in the class that used traditional teaching methods to see if the students favoured one teaching approach over the other. When the two lessons were finished, students completed the Student Interview and Survey in addition to the attitude scale (Appendix E). While the other students completed the survey, I randomly selected ten students to interview. The identical questions were asked in both the interview and the survey. To figure out which technique the students favoured, I compared the responses from both courses.

My principal saw a total of four classes, two from each class, to determine which method achieved the highest percent of participation. During a 5E Learning Cycle session and a typical teaching technique lesson, she observed each class. I made the Engagement Tally Chart, which she completed while watching (Appendix F). We prepared a list of off-task actions that indicated pupils weren't paying attention in class. Playing with things, crying out, talking during lectures, making noise, eyes wandering about the room, lying their heads on their desk, and being redirected were all examples of off-task behaviours. Four further group lessons were also videotaped. Each class was recorded twice: once during a 5E Learning Cycle lesson and once during a typical teaching methods lecture. I viewed the videos after recording the lessons and completed The Engagement Tally Chart for each lesson. I compared the checklist results to see which strategy resulted in the highest level of involvement. The Data Triangulation Matrix summarises the data sources and study questions (Table 1).

Table 1: Matrix of Data Triangulation

Research Questions	Data Source #1	Data Source #2	Data Source #3
1. What strategy produces a higher retention rate?	Teacher Made Pretest	Teacher Made Posttest	Student Generated Artifacts
2. What strategy do the students prefer?	Attitude Scales	Student Survey	Student Interviews
3. What strategy produces a higher percent of engagement?	Principal Observations	Engagement Tally Chart	Teacher Video Recording Observations

DATA ANALYSIS

According to the findings of the Student Interview and Survey, 83 percent of students (N = 36) chose to learn about science by completing the 5E Learning Cycle rather than traditional teaching techniques. "It's difficult for me to keep up with the other children when we read since I don't read very fluently," one youngster explained. Because it isn't right, I don't pay attention when we read about science." "When we perform the 5E Learning Cycle, I feel more immersed in the class," another student wrote. It simply makes more logic and is more enjoyable."

The Student Interview and Survey found that 86 percent of students learned more about science by completing the 5E Learning Cycle rather than listening to lectures and reading from a textbook. "I learn more from the 5E Learning Cycle because it is more fascinating, and I pay more attention when I'm more involved," a student explained. "I can feel and touch things," another kid added, explaining why he learned more. "The 5E Learning Cycle explains youngsters how, why, and what happens," says another student. "The 5E Learning Cycle helps us retain and use our (processing) abilities we gained like forecasting," another student noted.

Students who finished the 5E Learning Cycle averaged 72 percent on the Soils Posttest, while students who used traditional teaching techniques averaged 42 percent. Similar results were found in the Properties of Matter Posttest. On the Properties of Matter Posttest, students who completed the 5E Learning Cycle scored 87 percent, whereas those who used traditional teaching techniques scored 70 percent.

The Engagement Tally Chart revealed that 81 percent of off-task behaviours happened during traditional teaching technique classes after eight observations (Figure 1). Students laying their heads on their desks while reading the textbook accounted for 65 percent of off-task behaviours during traditional teaching methods classes. The Soil Attitude Scale revealed that 72 percent of the Traditional Group disagreed (n = 18) when asked if they preferred to read about soil. It also revealed that 83 percent of the students in the 5E Group who finished the soil course felt that they enjoy exploring soil (n = 18). According to the Properties of Matter Attitude Scale, 67 percent of students in the Traditional Group who finished the properties of matter unit disagreed with the statement I enjoy reading about properties of matter. It also revealed that 94 percent of students in the 5E Group who finished the properties of matter course indicated that they enjoy exploring the properties of matter.

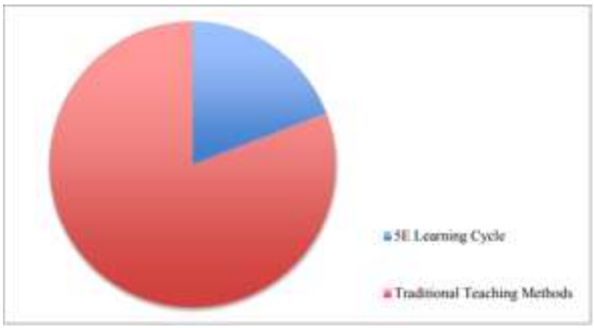

Figure 1: Incidents of off-task conduct (N = 47).

According to the findings of the Soils Pretest, 91 percent of pupils in both categories received a 50 percent or lower overall score. On the pretest, the 5E Group scored 33% on average, whereas the Traditional Group scored 29%. The 5E Group increased their average by 39% and scored an average of 72 percent on the Soils Posttest after completing the unit, whereas the Traditional Group increased their average by 18% and ended with an average of 47 percent (Figure 2). The findings of the Soils Posttest revealed that the 5E Group outperformed the Traditional Group across the board. They scored at least 20% higher on average across the board, with the biggest change in the critical thinking section of the test. The 5E Group scored 70% on average, whereas the Traditional Group scored 38%.

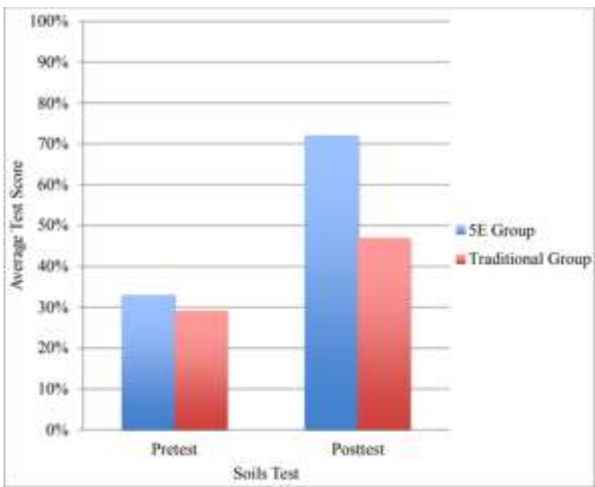

Figure 2: Yests of soils (N = 36).

Both groups started the Properties of Matter Unit after finishing the Soils Unit. The Traditional Group scored 39 percent on the Properties of Matter Pretest before starting the courses, compared to 32 percent for the 5E Group. After the lessons, the Traditional Group's average increased by 31% to a 70 percent average on the Properties of Matter Posttest, while the 5E Group's average increased by 55 percent to an 87 percent average (Figure 2). The Properties of Matter Posttest revealed that the 5E Group outperformed the Traditional Group in every section of the test. They improved by at least 10% in every section, with the most significant improvement in the critical thinking section of the test. The Traditional Group averaged 63 percent, while the 5E Group averaged 100 percent.

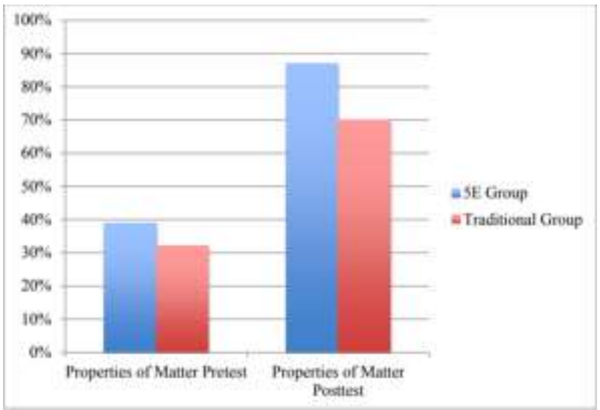

Figure 3: Properties of matter tests, (N = 36).

CONCLUSION

When compared to traditional teaching approaches, students reported a higher level of interest, were more engaged, and scored higher on examinations when using the 5E Learning Cycle. Students were able to indicate through surveys and interviews that they not only prefer the 5E Learning Cycle over traditional teaching techniques, but also that they believe they learn more about science, which is supported by their exam scores. It was evident which method resulted in a higher level of involvement. Students would continually put their heads on their desks and allow their eyes wander around the room while watching traditional instructional methods. After the engage phase of a 5E Learning Cycle lesson, students are hooked for the duration of the lesson. Because they were enthusiastic about what they were studying, the bulk of their off-task actions were shouting.

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Corresponding Author

Chandana Kumari*

Research Scholar, Department of Education, Brabu Muzaffarpur

chandu84.janvi@gmail.com