The Development of Mathematics Achievement on Exponents by the 5E of Inquiry-Based Learning for Grade 7 English Program Students at Demonstration School of Suan Sunandha Rajabhat University

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Abstract

In this research, we apply the 5E inquiry-based learning to investigate grade 7 English program students' mathematics achievement on the topic of exponents. Data were collected during the first semester of the 2025 academic year, with 12 50-minute lessons each. Data was analysed applying arithmetic means and relative gain scores. The results of this research showed that students who studied by using the 5E inquiry-based learning had high levels of relational gain scores.

Keywords: 5E inquiry-based learning, Exponents, Relative gain scores

1. Introduction

Mathematics is important to the development of human thinking, pushing logical, systematic, and methodical reasoning. This enables individuals to methodically and rigorously analyze problems or situations, as well as to forecast and develop appropriate solutions (Ministry of Education, 2017). The Cambridge University Dictionary (Mathematics, 2025) describes mathematics as "the study of numbers, shapes, and space using reason and usually a special system of symbols and rules for organizing them." It suggests that mathematics not only educates us in calculation but also in the utilization of symbolic systems for investigating various features of numerical systems.

In mathematics, exponents represent a fundamental concept underlying numerous basic topics in high school, including polynomials and polynomial factorization, conic sections, calculus, and statistics. Furthermore, exponents play an important role in various advanced university courses, including calculus, number theory, differential equations, and complex analysis (Rahn and Berndes, 1994). Regrettably, students frequently disregard numerous properties of exponents shortly after learning them and find it difficult to explain the underlying reasons for their validity (Weber, 2002). Therefore, it is crucial for mathematics educators to make sure that students perceive the fundamental origins of the numerous properties of exponents when educating this subject.

In 2021, Jampawai (Jampawai et al., 2021) mentioned that one of the factors affecting academic achievement in calculus is related to the teaching and learning activities are to use of appropriate and diverse educational materials. To solve this problem, teachers need to

improve and revise their teaching techniques in order by focusing on understanding the foundational principles underlying the properties of exponents, which will allow students to better retain and apply these properties. A review of pertinent literature and research demonstrates that the 5E inquiry-based learning is a student-centered approach that fosters critical thinking, reasoning, and active engagement in exploration and the construction of knowledge. The teacher facilitates various facets of the learning process, encouraging students to put forward questions, develop ideas, and effectively investigate knowledge to find their own answers or achieve conclusions. This knowledge may then be applied across different situations (Phonyiam and Prasertsang, 2024). In the same paper, they outlined the five stages of the 5E inquiry cycle, which contain the following steps:

Step 1: Engagement. This initial stage serves as the introduction to the lesson, connecting new material with learners' existing prior knowledge. Its purpose is to stimulate curiosity among the students. This phase may involve group discussions where the instructor and learners collaboratively formulate questions, utilizing **high-level questioning techniques**, specifically focusing on **Analysis Questions**.

Step 2: Exploration. In this stage, learners gain hands-on experience by conducting activities to gather and collect data, such as performing experiments or studying information from various sources and documents. This is a crucial step for developing conceptual understanding. The instructor and learners collaboratively formulate questions, utilizing **high-level questioning techniques**, specifically focusing on **Analysis Questions**.

Step 3: Explanation. Upon sufficient data acquisition, the learners proceed to analyze, interpret, and conclude the findings. The results are then presented in various formats, such as descriptive summaries, model construction, or diagramming. This phase is designed to enable learners to develop their ability to articulate the concepts derived during the Exploration stage. The instructor and learners collaboratively formulate questions, utilizing **high-level questioning techniques**, specifically focusing on **Analysis Questions**.

Step 4: Elaboration. This stage requires learners to link the knowledge they have constructed with their existing knowledge base, thereby extending or supplementing their comprehension and concepts. This process helps establish connections between the topic and various related issues, leading to a broader scope of knowledge. The instructor and learners collaboratively formulate questions, utilizing **high-level questioning techniques**, specifically focusing on **Application Questions** and **Synthesis Questions**.

Step 5: Evaluation. This constitutes the assessment of learning through various processes to determine what knowledge the learners possess, how they acquired it, and to what extent. The findings then guide the application of this knowledge to other contexts. Furthermore, this stage serves as the point where the instructor assesses the learners' overall knowledge and comprehension. The instructor and learners collaboratively formulate questions, utilizing **high-level questioning techniques**, specifically focusing on **Analysis Questions** and **Evaluation Questions**.

Based on the above discussion, we are interested in studying the relative gain scores of the first-year secondary school students in the English Program at Demonstration School of Suan Sunandha Rajabhat University, in the context of a classroom using the 5E inquiry cycle, on the topic of exponents, in order to provide guidelines for teaching and developing students' understanding of exponents at a higher level.

1.1 Research Objective

To investigate the learning achievement of first-year secondary school students in mathematics, specifically on the topic of exponents, before and after instruction using the 5E inquiry cycle.

2. Methodology

2.1 Target Group

The target group for this research consisted of 28 students in the grade 7 in the English Program at Demonstration School of Suan Sunandha Rajabhat University, during the first semester of the 2025 academic year.

2.2 Research Instruments

2.2.1 Lesson Plans

The researcher developed three lesson plans on the topic of exponent using the 5E inquiry-based learning 28 students. The lessons were conducted over 12 periods, with each period lasting 50 minutes, as detailed below:

Lesson Plan 1: Definition and Meaning of Exponents

Lesson Plan 2: Properties of Exponents (I)

Lesson Plan 3: Properties of Exponents (II)

2.2.2 Mathematical Test

Researchers developed a 20-item multiple-choice test to measure understanding and application of the properties of exponents, and submitted it to two experts for content validity review.

2.3 Data Collection

This study applied a quasi-experimental design with a single-group pretest-posttest method (Tirakanun, 2007). The researcher carried out the experiment and collected data from the target students to evaluate their mathematical problem-solving skills regarding exponents, applying the 5E inquiry-based learning. Data were gathered at the Demonstration School of Suan Sunandha Rajabhat University. The procedures for data collection were carried out as follows:

1. The researcher outlined the preliminary agreements to the target students concerning the learning objectives, assessment standards, and evaluation procedures.

2. A pretest was conducted utilizing a 20-item multiple-choice evaluation created by the researcher to evaluate students' mathematical problem-solving skills.

3. The instruction was delivered in accordance with the pre-established lesson plans across 12 periods during the first semester of the 2025 academic year.

4. Following the completion of all scheduled learning activities, a posttest was conducted utilizing the same assessment as the pretest.

5. The researcher subsequently examined the collected data from the assessments to assess the students' learning outcomes.

2.4 Data Analytical

1. The pretest and posttest assessing students' academic achievement were scored, both before and after applying the 5E inquiry-based learning.

2. **Assessing the Improvement in Problem-Solving Ability**

The development of Grade 7 students' mathematical problem-solving abilities after learning through the 5E inquiry-based learning. was measured using relative gain scores calculated from the pretest and posttest using the following formula (Kanchanawasi, 1995):

$$\text{Relative Gain Score (RGS)} = \frac{x_2 - x_1}{F - x_1} \times 100,$$

where x_1 = pretest score, x_2 is the posttest score, and F is full score.

3. **Analysis of Academic Achievement Development**

Relative gain scores were interpreted according to the following criteria (Hortrakul et al., 2024):

75 – 100%	mean	Very high Level
50 – 74.9%	mean	High Level
25 – 49.9%	mean	Intermediate Level
0 – 24.9%	mean	Initial Level

3. Results

This study investigated the educational achievement in mathematics through the application of the 5E inquiry-based learning for grade 7 English program students who were in the English program at the Demonstration School of Suan Sunandha Rajabhat University. The data was gathered on test scores, and students' academic achievement was assessed both pretest and posttest. The subsequent calculations of relative gain scores were derived from these scores, as illustrated in the following tables.

Table 1: the pre-test, post-test, and percentage gain scores of first-year secondary school students in each class.

M1/1				M1/2			
Student Number	Pretest Score	Posttest Score	RGS	Student Number	Pretest Score	Posttest Score	RGS
1	3	16.00	76.47	1	8	20.00	100.00
2	2	14.00	66.67	2	2	13.00	61.11
3	3	12.00	52.94	3	2	12.00	55.56
4	1	11.00	52.63	4	0	12.00	60.00
5	2	10.00	44.44	5	2	13.00	61.11
6	4	18.00	87.50	6	1	12.00	57.89
7	1	12.00	57.89	7	2	14.00	66.67
8	2	13.00	61.11	8	2	15.00	72.22
9	2	11.00	50.00	9	3	18.00	88.24

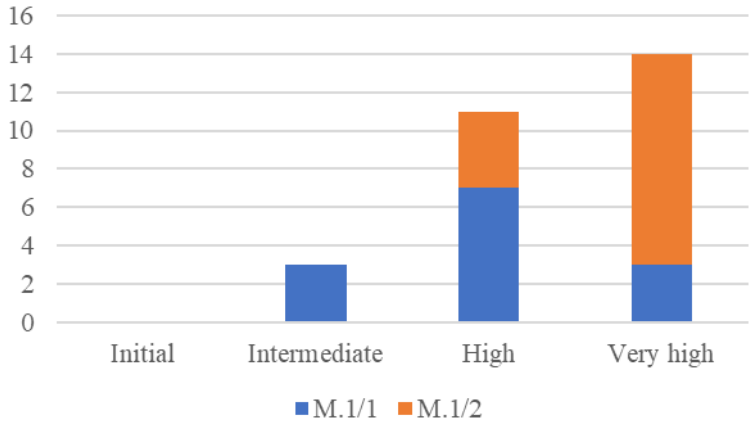
M1/1				M1/2			
Student Number	Pretest Score	Posttest Score	RGS	Student Number	Pretest Score	Posttest Score	RGS
10	2	16.00	77.78	10	2	17.00	83.33
11	4	15.00	73.68	11	1	15.00	73.68
12	2	14.00	66.67	12	9	20.00	100.00
13	0	10.00	50.00	13	1	14.00	68.42
				14	2	14.00	66.67
				15	1	13.00	63.16
Average	2.15	13.23	62.53	Average	2.8	14.80	71.63

Table 2: the pre-test, post-test, and percentage gain scores of first-year secondary school students.

	Average Score
Pretest Scores	2.36
Posttest Scores	14.07
Relative Gain Scores	67.53

The results, which include pre-test, post-test, and Relative Gain Scores (RGS), indicate a **statistically significant increase** in the average post-test scores for students in both groups. This notable improvement is evident when considering the very low overall mean pre-test score ($\overline{X_{pre}}$ = 2.36) compared to the substantially higher overall mean post-test score $\overline{X_{post}}$ = 14.07 Furthermore, an analysis of the **Mean Relative Gain Score (Mean RGS)**, which serves as an indicator of the instructional intervention's effectiveness, reveals that the students collectively achieved a mean relative gain of **67.53%**. Specifically, Classroom M.1/2 demonstrated a higher mean relative gain of **71.87%**, exceeding that of Classroom M.1/1, which recorded a mean relative gain of **62.53%**

Figure 1: the number of students at each level of relative gain scores.



An analysis of student performance by applying the Relative Gain Score (RGS) indicates that the 5E inquiry-based learning learning successfully improves their understanding of exponents. No students were found to be at an Initial level of development; most exhibited high to very high levels of development. In class M.1/2, 11 students reached exceptionally high achievement (>80%), proving that the 5E inquiry-based learning supports independent knowledge construction and increases understanding of concepts.

4. Conclusion

Based on the overall average RGS score of 67.53% according to the interpretation criteria defined by Hortrakul et al., the results suggest that the 5E inquiry-based learning significantly improved conceptual understanding of exponents, particularly in class M.1/2, where the RGS score approached the high development criterion. This shows the effectiveness of the teaching in facilitating students' achievement of their learning potential. T the 5E inquiry-based learning for teaching exponents significantly raised the conceptual understanding scores of M.1 students at the .05 statistical significance level, indicating that the 5E inquiry-based learning successfully contributes to improved student achievement.

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