การเรียนรู้แบบสืบเสาะ 5 ขั้น ร่วมกับบทเรียนออนไลน์บนยูทูป เรื่องถ่านหินและปิโตรเลียม ที่มีต่อผลสัมฤทธิ์ทางการเรียนและความพึงพอใจต่อการเรียนของนักศึกษา

5-STEP OF INQUIRY-BASED LEARNING WITH ONLINE YOUTUBE LESSONS ON COAL AND PETROLEUM FOR STUDENT ACADEMIC ACHIEVEMENT AND LEARNING SATISFACTION

สมสุข ไตรศุภกิตติ[1], ปิยนันท์ เกตุแสง[2,*], นันทพร ยิ่งรัตนสุข[3], และวัชรา เสนาจักร์[4]

Somsuk Trisupakitti[1], Piyanan Katesaeng[2,*], Nunthaporn Yingratanasuk[3], and Watchara Senajuk[4]

[1-3]คณะวิทยาศาสตร์และเทคโนโลยี มหาวิทยาลัยราชภัฏมหาสารคาม

[4] มหาวิทยาลัยราชภัฏวไลยอลงกรณ์ ในพระบรมราชูปถัมภ์

[1-3]Faculty of Science and Technology, Rajabhat Maha Sarakham University,

[4] Valaya Alongkorn Rajabhat University under the Royal Patronage

*Corresponding author's E-mail: pkatesaeng@gmail.com

บทคัดย่อ

การวิจัยนี้มีวัตถุประสงค์เพื่อ 1) พัฒนากิจกรรมการเรียนรู้แบบสืบเสาะหาความรู้ 5 ขั้น ร่วมกับ บทเรียนออนไลน์บนยูทูป เรื่องถ่านหินและปิโตรเลียม ให้มีประสิทธิภาพตามเกณฑ์ 80/80 2) เปรียบเทียบ ผลสัมฤทธิ์ทางการเรียนก่อนเรียนและหลังเรียนที่จัดการเรียนรู้แบบสืบเสาะหาความรู้ 5 ขั้น ร่วมกับบทเรียน ออนไลน์บนยูทูป เรื่องถ่านหินและปิโตรเลียม 3) ศึกษาความพึงพอใจของผู้เรียนที่มีต่อการเรียนรู้แบบ สืบเสาะหาความรู้ 5 ขั้น ร่วมกับบทเรียนออนไลน์บนยูทูป เรื่องถ่านหินและปิโตรเลียม กลุ่มตัวอย่างที่ใช้เป็น นักศึกษาที่ลงทะเบียนเรียนรายวิชาวิทยาศาสตร์พลังงาน ภาคเรียนที่ 1 ปีการศึกษา 2567 มหาวิทยาลัย ราชภัฏมหาสารคาม จำนวน 16 คน เครื่องมือที่ใช้ในการวิจัย ได้แก่ 1) บทเรียนออนไลน์บนยูทูป เรื่องถ่านหิน และปิโตรเลียม จำนวน 4 บทเรียน 2) แผนการจัดการเรียนรู้แบบสืบเสาะหาความรู้ 5 ขั้น ร่วมกับบทเรียน ออนไลน์บนยูทูป เรื่องถ่านหินและปิโตรเลียม 3) แบบทดสอบวัดผลสัมฤทธิ์ก่อนเรียนและหลังเรียนต่อการ เรียนรู้แบบสืบเสาะหาความรู้ 5 ขั้น ร่วมกับบทเรียนออนไลน์บนยูทูป เรื่องถ่านหินและปิโตรเลียม 4) แบบสอบถามความพึงพอใจของนักศึกษาต่อการเรียนรู้แบบสืบเสาะหาความรู้ 5 ขั้น ร่วมกับบทเรียน ออนไลน์บนยูทูป เรื่องถ่านหินและปิโตรเลียม การวิเคราะห์ข้อมูล ได้แก่ ที-เทส ค่าเฉลี่ย ร้อยละ และส่วน เบี่ยงเบนมาตรฐาน ผลการวิจัยพบว่า 1) กิจกรรมการเรียนรู้แบบสืบเสาะหาความรู้ 5 ขั้น ร่วมกับบทเรียน ออนไลน์บนยูทูป เรื่องถ่านหินและปิโตรเลียม มีประสิทธิภาพเท่ากับ 82.50/81.38 2) ผู้เรียนมีผลสัมฤทธิ์ ทางการเรียนรู้แบบสืบเสาะหาความรู้ 5 ขั้น ร่วมกับบทเรียนออนไลน์บนยูทูป เรื่องถ่านหินและปิโตรเลียม

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[1] สาขาวิชาเคมี, [2]สาขาสถิติประยุกต์, [3]สาขาคณิตศาสตร์, [1-3]คณะวิทยาศาสตร์และเทคโนโลยี มหาวิทยาลัยราชภัฏมหาสารคาม

[1] Department of Chemistry, [2]Department of Applied Statistics, [3]Department of Mathematics,

[1-3] Faculty of Science and Technology, Rajabhat Maha Sarakham University,

[4] ปริญญาเอกสาขาวิชาวิทยาศาสตรศึกษา มหาวิทยาลัยราชภัฏวไลยอลงกรณ์ ในพระบรมราชูปถัมภ์

[4] Doctor of Science Education of Valaya Alongkorn Rajabhat University under the Royal Patronage

หลังเรียนสูงกว่าก่อนเรียนอย่างมีนัยสำคัญทางสถิติที่ระดับ .05 3) ผู้เรียนมีความพึงพอใจต่อการเรียนรู้แบบ สืบเสาะหาความรู้ 5 ขั้น ร่วมกับบทเรียนออนไลน์บนยูทูป เรื่องถ่านหินและปิโตรเลียม อยู่ในระดับมาก

คำสำคัญ: การเรียนรู้แบบสืบเสาะ 5 ขั้น, บทเรียนออนไลน์, ยูทูป, ถ่านหินและปิโตรเลียม

Abstract

This study aimed to: 1) develop a 5-step inquiry-based learning approach using YouTube online lessons on the topics of Coal and Petroleum, ensuring efficiency based on an 80/80 criterion; 2) compare students' academic achievements before and after implementing the 5-step inquiry-based learning with these online lessons; and 3) assess learners' satisfaction with this instructional method. The sample included 16 students enrolled in the Energy Science course during the first semester of the 2024 academic year at Rajabhat Maha Sarakham University. The research tools included: 1) four online YouTube lessons on Coal and Petroleum, 2) a structured plan for 5-step inquiry-based learning with YouTube lessons on these topics, 3) pre- and post-learning achievement tests, and 4) a satisfaction questionnaire regarding the 5-step inquiry-based learning experience with YouTube lessons. Data analysis involved t-tests, mean scores, percentages, and standard deviations. The results indicated that: 1) the 5-step inquiry-based learning approach with YouTube lessons on Coal and Petroleum achieved an efficiency score of 82.50/81.38, surpassing the target criterion; 2) post-learning achievement scores were significantly higher than pre-learning scores at the .05 level; and 3) learner satisfaction with the 5-step inquiry-based approach using YouTube lessons was high.

Keywords: 5-step Inquiry-Based Learning, Online Lessons, YouTube, Coal and Petroleum

Introduction

In science education, enhancing students' understanding of scientific concepts has consistently been a primary goal. Varma, Volkmann, and Hanuscin (2009) emphasized the need to integrate investigative practices within science teaching and learning. Effective science education should include activities such as observing, questioning, consulting diverse information sources, examining, collecting data, analyzing, predicting, interpreting, and communicating findings. Merely memorizing facts does not build scientific skills; however, fostering exploration and investigation through Inquiry-Based Learning (IBL) can. Engaging in IBL allows students to collect and analyze data, solve problems, and acquire new knowledge, promoting critical thinking and problem-solving abilities that go beyond rote learning. IBL

empowers students to explore, reason, and structure information, leading to a deeper integration of new knowledge with their prior understanding. According to Miller et al. (2010), IBL enhances students' understanding of the world while cultivating their problem-solving and critical thinking skills. By encouraging students to build on their existing knowledge and link it with new information, IBL supports a comprehensive and meaningful learning approach. In the digital age, IBL is an essential educational strategy that fosters problem-solving and critical thinking skills, which are vital for navigating modern complexities and are highly valued in the workforce. IBL teaches students to not only ask questions and seek answers but also to determine which questions are most relevant. This approach promotes cognitive skill integration across disciplines, enabling students to apply their knowledge in various contexts. With rapid advancements in science and technology, education in these fields is increasingly crucial for shaping the future. The profound impact of science and technology on everyday life highlights the need to equip students with the skills necessary for success in a dynamic world. Bransford et al. (2000) emphasized the importance of developing "scientific competence" as a core goal of science education, advocating for inquiry-based teaching approaches grounded in research on learning processes to meet these educational objectives.

Inquiry-based science courses immerse children in the activities and thought processes that scientists use to build knowledge. Science educators advocate moving away from traditional, teacher-centered methods to embrace inquiry-based approaches that stimulate curiosity, provide hands-on experiences, and challenge students to apply logic and evidence. This approach encourages students to develop explanations, emphasizes the importance of evidence-based writing, and creates a collaborative classroom environment that mirrors the dynamics of scientific communities. Such an environment is crucial for fostering scientific thinking and behavior, engaging students in discovery and knowledge validation. Conventional teacher-centered methods can limit student engagement, restricting opportunities for independent thinking, questioning, and peer interaction, which are essential for developing critical thinking and a deeper understanding of scientific principles. To promote scientific literacy and enthusiasm for learning, educators need to adopt a student-centered approach that encourages inquiry, collaboration, and critical thinking, forming a "community of practice" within the classroom that fosters a deeper grasp of scientific concepts and a genuine love of learning (Lord, 1999; Sandoval & Reiser, 2004; Secker, 2002). Structured inquiry allows teachers to introduce a problem and provide the

necessary procedures and materials, guiding students through a specific concept or skill. This can evolve into open inquiry, where students generate their own questions for exploration. As Marshall (2009) highlighted, inquiry-based learning is an effective way to build student-centered learning environments, helping students to organize new information, test ideas, and develop evidence-based thinking. Thus, inquiry-based learning is recognized as a student-centered strategy that facilitates knowledge building (Koseoglu & Tumay, 2010). It nurtures essential inquiry skills, critical for the 21st century (Kong & Song, 2014). Inquiry-based learning, rooted in constructivist theory, enhances critical thinking, curiosity, and exploration. Through hands-on activities, such as experiments and observations, students engage in scientific methods, empowering them to take ownership of their learning and develop a lifelong passion for knowledge (Colburn, 2000; Keselman, 2003; NRC, 2000; Pedaste, Mäeots, Leijen, & Sarapuu, 2012). By fostering curiosity, encouraging questions, and promoting research and experimentation, inquiry-based learning boosts motivation, problem-solving abilities, and subject comprehension (Lord & Orkwiszewski, 2006; Wilke & Straits, 2005). When students take responsibility for their learning, they develop a sense of ownership and confidence in their abilities.

Different types of inquiry-based learning—structured, guided, and open—offer varied opportunities for exploration and discovery, which can positively impact students' academic and personal growth (Colburn, 2000; Wilke & Straits, 2005). This study utilized the guided inquiry approach, where teachers acted as facilitators, students formulated their questions and methods, and new concepts emerged from connections with prior knowledge (Colburn, 2000). Aligned with constructivist principles, guided inquiry learning has shown to yield more effective learning outcomes compared to other inquiry forms (Koseoglu & Tumay, 2010; Minner, Levy, & Century, 2009). The 5-step Inquiry-Based Learning (IBL) model in science classes promotes active student engagement through five stages: engagement, exploration, explanation, elaboration, and evaluation. In the engagement stage, students build curiosity and assess prior knowledge, sparking interest in the topic. The exploration stage encourages investigation and question-solving, with teachers guiding through questions and real-world connections. Elaboration lets students apply knowledge practically, while evaluation measures progress and provides feedback throughout the learning process. By collaborating, sharing perspectives, and using technology, students develop scientific skills, connecting new experiences with previous knowledge for deeper understanding (Bybee et al., 2006; Colburn, 2007; Wilder & Shuttleworth, 2005).

The 5-step IBL method centers on learners, training them to independently search for information and solve problems through reasoning. Teachers play a crucial supporting role, preparing teaching materials and designing activities to foster a collaborative learning environment. In the 5-step IBL process, teachers guide and facilitate students' learning, ensuring they engage fully in each stage (BSCS, 2019; Bybee, 2009).

1. Creating Interest (Engagement): Teachers should engage students by sparking curiosity and encouraging critical thinking. This can be done through activities like observing images, watching videos or demonstrations, participating in kinesthetic activities, and free writing.

2. Exploring and Searching (Exploration): Teachers should encourage collaborative exploration, investigation, and questioning among students, guiding them through hands-on activities to understand concepts. This includes asking testable questions, forming and testing hypotheses, gathering and analyzing data, drawing conclusions, and communicating results.

3. Explanation and Conclusion (Explanation): In this phase, teachers encourage students to deepen their understanding by explaining concepts in their own words, providing evidence, and elaborating on details. This process helps students solidify their knowledge, make connections, and build confidence in their understanding. Teachers play an active role in guiding this phase, using explanations, defining essential terms, and fostering interactive discussions to enhance comprehension. Resources such as textbooks, leveled readers, and articles are integrated to offer diverse perspectives and reinforce the information, helping students to confirm and expand on what they've learned.

4. Elaboration: Teachers encourage students to apply their knowledge to new situations, explain meaningfully, and provide evidence-based answers. Activities in this phase include debates, passion-based learning, lab experiments, and exploring topics like current science issues and careers, allowing students to extend and apply their learning.

5. Evaluation: Teachers assess students' understanding by observing their application of concepts, evaluating knowledge and skills, and noting changes in thinking or behavior. Students engage in self-assessment, performance-based assessments, work portfolios, evidence-based reasoning, and final presentations to reflect on and demonstrate their learning.

The 5-step IBL approach prioritizes learners, enhancing teaching effectiveness when learners understand their roles. This method supports self-directed information-seeking

through reasoning, fostering knowledge, skills, and competencies applicable in real-life contexts. In this study, the 5-step IBL model was applied to online YouTube lessons on "Coal and Petroleum" to evaluate its impact on student efficiency and academic achievement in the Energy Science course during the first semester of 2024.

Objectives

1) To develop a 5-step Inquiry-Based Learning (IBL) module on "Coal and Petroleum" with online lessons available on YouTube, ensuring it meets the efficiency standard of 80/80.

2) To compare students' learning achievement results before and after using the 5-step Inquiry-Based Learning (IBL) approach with online YouTube lessons on "Coal and Petroleum."

3) To assess learner satisfaction after implementing the 5-step Inquiry-Based Learning (IBL) approach with online YouTube lessons on "Coal and Petroleum."
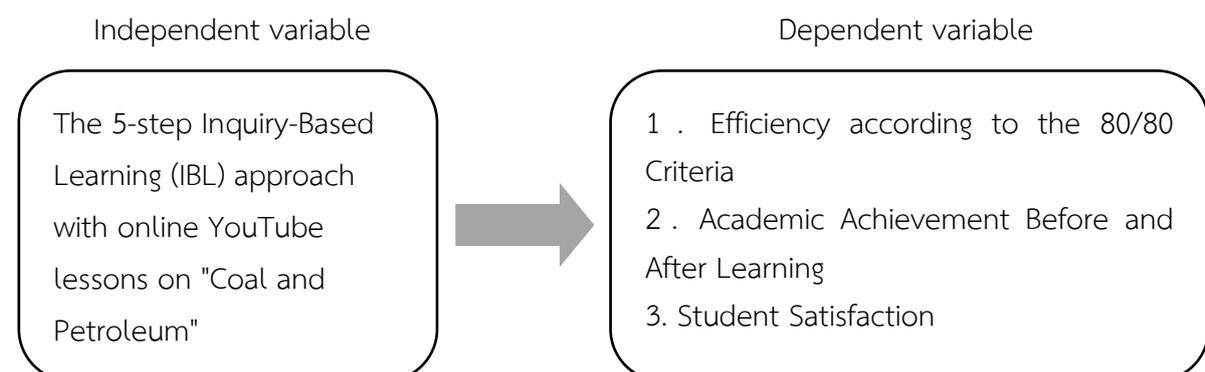
Research Hypothesis

In this study, the conventional probability threshold of $p < 0.05$ was consistently applied to determine that effects were unlikely due to random variation. The findings are as follows:

1) The 5-step Inquiry-Based Learning (IBL) module with online YouTube lessons on "Coal and Petroleum" achieved an efficiency level of at least 80/80.

2) Students who participated in the 5-step IBL with online YouTube lessons on "Coal and Petroleum" demonstrated higher learning achievement after the lessons compared to before.

3) Students who engaged with the 5-step IBL module via YouTube lessons on "Coal and Petroleum" reported a high level of satisfaction with the learning experience.

Conceptual Framework for Research

Independent variable		Dependent variable
The 5-step Inquiry-Based Learning (IBL) approach with online YouTube lessons on "Coal and Petroleum"	→	1 . Efficiency according to the 80/80 Criteria 2 . Academic Achievement Before and After Learning 3. Student Satisfaction

Methodology

This research used a one group pretest and posttest design - see Table 1.

Table 1 Design of the single group pre- and post-experimental study

Group	Pre-test	Treatment	Post-test
Experimental students	T_1	X	T_2

where, T_1 was pre-test, X was treatment and T_2 was post-test.

The population and sample for this study consisted of 16 students enrolled in the Energy Science course at Rajabhat Maha Sarakham University during the first semester of the 2024 academic year.

The research instruments used in this study included the following:

1) Online Lessons on YouTube: "Coal and Petroleum" – A series of four online lessons covering the topic, with a total study duration of 600 minutes.

2) 5-Step IBL Plan with Online Lessons on YouTube: "Coal and Petroleum" – A structured instructional plan based on the 5-step Inquiry-Based Learning approach, designed to guide students through the topic interactively.

3) Pre- and Post-Study Achievement Test – An assessment to measure students' learning progress before and after the intervention, consisting of 50 multiple-choice questions with 4 answer options per question.

4) Student Satisfaction Questionnaire – A survey to gauge students' satisfaction with the learning experience, using a 5-point Likert scale (Likert, 1961) with levels: very high, high, moderate, low, and very low.

Average suitability scores were mapped to:

$4.51 – 5.00 \rightarrow$ very high $\qquad 3.51 – 4.50 \rightarrow$ high

$2.51 – 3.50 \rightarrow$ moderate $\qquad 1.51 – 2.50 \rightarrow$ low

$1.00 – 1.50 \rightarrow$ very low level

In this study, data analysis included calculating the mean, percentage, standard deviation, and performing a dependent sample t-test to evaluate the effects of the 5-step Inquiry-Based Learning (IBL) approach with online lessons on "Coal and Petroleum." The following steps outline the data collection and analysis process:

1) Sample Selection – Sixteen students enrolled in the Energy Science course, Semester 1, Academic Year 2024, were selected as the study's sample group.

2) Research Orientation – The purpose, methods, and expectations for participation were explained to the students to ensure clear understanding and informed involvement.

3) Activity and Role Explanation – Students were briefed on the steps and their roles in engaging with the 5-step IBL process using the YouTube lessons on "Coal and Petroleum."

4) Pre-Test Administration – Students took a pre-test based on an achievement test that had been refined to accurately measure initial knowledge.

5) Implementation of 5-Step IBL with Online Lessons – The 5-step IBL lessons on YouTube were conducted, covering four topics on "Coal and Petroleum" (refer to Figure 1).

6) Engagement in Activity Sheets – Students completed activities laid out in three structured activity sheets, aligning with the learning management plan.

7) Post-Test and Satisfaction Questionnaire – At the end of the instructional plan, students took a post-test and completed a satisfaction questionnaire.

8) Data Analysis – Scores from the achievement test and responses from the satisfaction questionnaire were analyzed using the mean, percentage, standard deviation, and a dependent sample t-test to formally test the study's hypotheses.

| Petroleum 1 | Petroleum 2 | Petroleum 3 | Petroleum 4 |

Figure 1 QR code for online lessons (www.inklab.teachable.com)

Results

The hypothesis tested in this study was as follows:

Hypothesis 1: The 5-step Inquiry-Based Learning (IBL) approach with online lessons on YouTube covering "Coal and Petroleum" would achieve an efficiency level not lower than the 80/80 criterion.

This hypothesis was tested to determine if the instructional method met or exceeded the targeted standard, indicating that at least 80% of students would achieve 80% proficiency in the content covered. The results of data analysis are shown in Table 2.

Table 2 Effectiveness of 5-step IBL with online lessons on YouTube: Coal and Petroleum.

Test	Full score	Average score	Percentage
During study	70	57.75	82.50
Post-test	50	40.69	81.38
Efficiency is expressed as a percentage (E_1/E_2)			82.50/81.38

Table 2 reveals that the 5-step Inquiry-Based Learning (IBL) approach with online lessons on YouTube for "Coal and Petroleum," covering four sub-topics, achieved an efficiency (E1/E2) score of 82.50/81.38. This result surpasses the target criterion of 80/80, indicating that the instructional approach effectively engaged students and facilitated learning beyond the expected level. The higher-than-target efficiency score supports Hypothesis 1, confirming that students showed a strong interest in the lesson activities, which contributed to the enhanced efficiency of the learning experience.

Hypothesis 2 : Students who participate in the 5-step Inquiry-Based Learning (IBL) approach with online lessons on YouTube for "Coal and Petroleum" will demonstrate higher academic achievement after the learning sessions than before.

This hypothesis aims to assess the effectiveness of the IBL approach in enhancing students' knowledge and understanding of the topic, as measured by a comparison of pre- and post-learning test scores.

In the study, Table 3 presents the results of a dependent sample t-test, comparing students' scores before and after learning with the 5-step Inquiry-Based Learning (IBL) approach using online lessons on YouTube for "Coal and Petroleum." This statistical analysis evaluates the significance of any increase in academic achievement following the instructional intervention.

Table 3 Pre- and post-learning scores of 5-step IBL with online lessons on YouTube: Coal and Petroleum

Test	N	Scores	Total scores	Mean	*SD*	D	t	Sig.
Pre-test	16	50	274	17.13	5.03	23.56	17.32	≤ 0.0001
Post-test	16	50	651	40.69	2.96			

Table 3 demonstrates a significant improvement in students' academic achievement after participating in the 5-step Inquiry-Based Learning (IBL) approach with online lessons on YouTube for "Coal and Petroleum."

- **Before studying**, the average achievement score was 17.13 (*SD* = 5.03).
- **After studying**, the average score increased to 40.69 (*SD* = 2.96).

The dependent sample t-test yielded a t-value of 17.32, with a significance level of ≤ 0.0001, which is well below the threshold of p = 0.05. This statistically significant result supports Hypothesis 2, indicating that students' achievement scores improved substantially following the IBL intervention. This finding underscores the effectiveness of the 5-step IBL method in enhancing academic performance in the topic of "Coal and Petroleum."

Additionally, Figure 2 illustrates the percentage scores before and after learning, visually demonstrating the improvement in student performance post-intervention. These results support the assessment of Hypothesis 2, providing insights into the effectiveness of the 5-step IBL approach on student achievement.
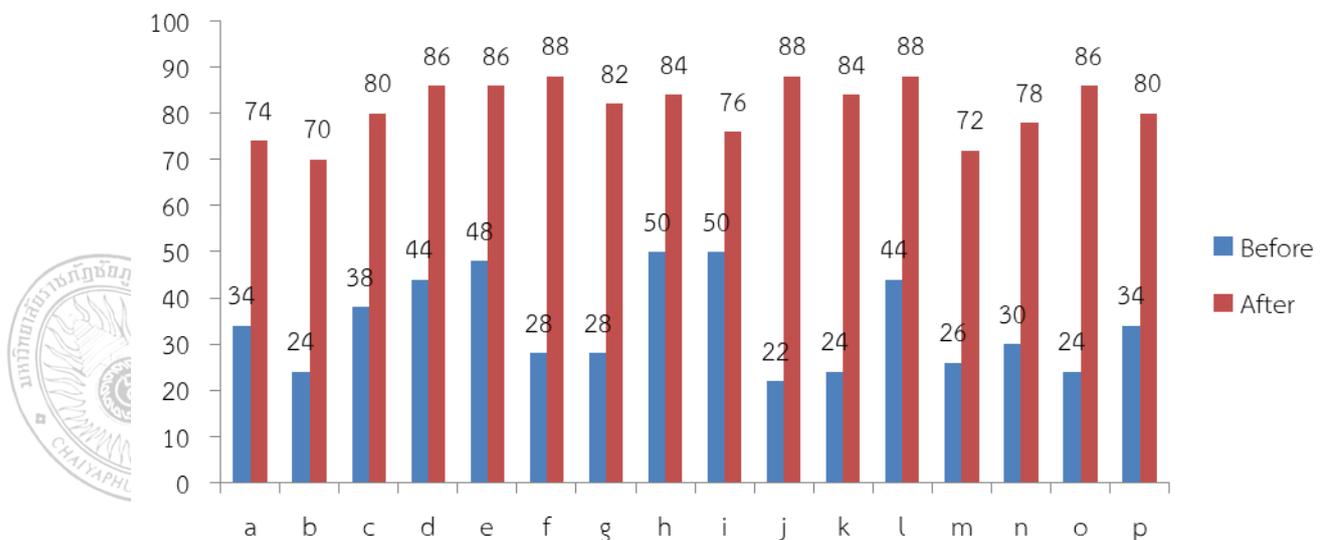

Figure 2 Pre-test and post-test scores (as %) of 16 students

Hypothesis 3: Students who participate in the 5-step Inquiry-Based Learning (IBL) approach with online lessons on YouTube for "Coal and Petroleum" will report a high level of satisfaction with their learning experience.

This hypothesis seeks to evaluate students' satisfaction with the IBL instructional approach, which was measured through a satisfaction questionnaire using a 5-point Likert scale. High satisfaction levels would indicate that the interactive and structured nature of the IBL method effectively engaged students and met their learning expectations, thereby supporting the instructional quality and appeal of the online lessons. The results of the questionnaire on student satisfaction are shown in Table 4 (mean = 3.51 – 4.50).

Table 4 reveals that students expressed high overall satisfaction with the 5-step Inquiry-Based Learning (IBL) approach using online lessons on YouTube for "Coal and Petroleum," with an average satisfaction score of 4.23±0.67, indicating a high satisfaction level. When examining each aspect of satisfaction, the areas ranked from highest to lowest mean scores are as follows:

1. **Measurement and Evaluation** – Highest satisfaction with an average score of 4.31±0.63.
2. **Media and Learning Equipment** – Second highest with an average score of 4.23±0.66.
3. **Learning Content** – Scored an average of 4.20±0.67.
4. **Learning Activities** – Received an average score of 4.16±0.73.

These results support **Hypothesis 3**, confirming that students found the 5-step IBL method effective and satisfying across multiple aspects of the learning experience.

Table 4 Questionnaire on student satisfaction

Items	Mean	SD	Interpretation
Learning Content			
1. Alignment with Energy Science Subject: The content should be directly relevant to the topics and principles within the Energy Science curriculum, ensuring it aligns with the learning goals of the course.	4.63	0.50	very high
2. **Accuracy and Completeness**: The content must be accurate, covering all essential information outlined in the objectives for the topic of Petroleum, providing students with a comprehensive understanding.	4.25	0.45	high

Items	Mean	SD	Interpretation
3. **Appropriateness for Study Duration**: The content should be structured to fit within the designated study time, ensuring that it is neither too dense nor too light for the allotted period.	3.94	0.93	high
4. **Clarity and Comprehensibility**: The information should be presented clearly, using language and examples that make it easy for students to understand and retain.	4.25	0.77	high
5. **Relevance to Daily Life**: The content should demonstrate practical connections to everyday life, helping students see the real-world applications of what they are learning about energy sources like petroleum.	3.94	0.68	high
Average learning content	4.20	0.67	high
Learning Activities			
1. **Alignment with Content**: Activities and worksheets should be directly relevant to and reinforce the content covered, ensuring cohesion between learning materials and tasks.	4.63	0.50	very high
2. **Interest and Engagement**: The activities and worksheets should be designed to capture students' interest, encouraging curiosity and active participation in the learning process.	4.00	0.63	high
3. **Emphasis on Participation and Hands-On Learning**: Activities should prioritize learner involvement and provide opportunities for hands-on experiences, enabling students to actively engage and apply what they learn	4.06	0.93	high
4. **Promotion of Scientific Process Skills**: The worksheets and activities should encourage the development of scientific skills, such as observation, analysis, hypothesis testing, and critical thinking, fostering a deeper understanding of scientific concepts	4.25	0.77	high
5. **Appropriate Use of Technology and Innovation**: Technology or innovative tools should be incorporated thoughtfully to enhance the learning experience, ensuring they are used in ways that support and enrich learning outcomes.	3.88	0.81	high
Average organizing learning activities	4.16	0.73	high

Items	Mean	SD	Interpretation
Media and Learning Equipment			
1. **Consistency with Content**: Media and equipment should align directly with the content, supporting and enhancing the topics covered in the lessons.	4.44	0.51	high
2. **Promotion of Interest and Engagement**: Media and equipment should be designed or selected to capture students' attention and stimulate their interest, helping make the learning experience more engaging.	4.19	1.10	high
3. **Suitability for Use**: The media and equipment should be appropriate for the educational context, ensuring ease of use and suitability for the age and skill level of the students.	4.00	0.63	high
4. **Appropriateness with Content and Activities/Worksheets**: Media and equipment should complement the content and activities/worksheets, creating a seamless integration that enhances learning without distraction.	4.06	0.93	high
5. **Sufficiency and Readiness for Research**: There should be an adequate supply and readiness of media, equipment, and tools, ensuring that all resources are available and prepared to support the learning and research processes effectively.	4.44	0.81	high
Average media and learning equipment	4.23	0.66	high
Measurement and Evaluation			
1. **Alignment with Learning Objectives**: The measurement and evaluation methods should directly reflect the learning objectives, ensuring they assess the intended outcomes of the lessons.	4.06	0.68	high
2. **Consistency with Learning Activities/Worksheets**: Evaluation should be designed to assess skills and knowledge related to the activities and worksheets, supporting a cohesive learning experience.	4.25	0.77	high
3. **Transparency of Scores**: Scores and results from evaluations should be openly shared with students to help them understand their progress and areas of strength or improvement.	4.44	0.81	high

Items	Mean	SD	Interpretation
4. **Clarity and Fairness**: The evaluation process should be straightforward and equitable, providing all students with an equal opportunity to demonstrate their understanding.	4.63	0.50	very high
5. **Constructive Feedback for Self-Development**: Feedback should be given in a way that encourages students to reflect on their performance and guides them in identifying areas for improvement, fostering continuous self-development.	4.19	0.40	high
Average measurement and evaluation	4.31	0.63	high
Total average	4.23	0.67	high

Discussion

The qualitative analysis of observations, surveys, and interviews conducted before, during, and after implementing a 5-step Inquiry-Based Learning (IBL) approach, combined with YouTube lessons on the topic of "Coal and Petroleum," underscores the effectiveness of student-centered methodologies in deepening student engagement and comprehension.

1. Empowering Learner-Centered Approach: The 5-step IBL model engages students through a series of structured, inquiry-based activities that encourage exploration and hypothesis formation. Students actively engage by asking questions, developing hypotheses, and conducting independent research, which centers their learning experience a round self-discovery and analysis. This model fosters independence and critical thinking, with teachers guiding as mentors, rather than direct instructors, to support students in sourcing information and tackling challenges effectively.

2. Enhancement through Technology Integration: Incorporating YouTube as an online learning tool has shown to greatly increase student engagement by making content more accessible and appealing. The analysis highlights that the use of technology, particularly YouTube's visual and interactive capabilities, boosts student motivation, allowing them to dive deeper into the content. Through collaborative activities and peer-sharing, students expand upon teacher-led lessons, building their analytical abilities and honing their skills in synthesizing information collaboratively.

3. Advantages of Online Learning Media: YouTube lessons allow students to learn at their own pace, providing the flexibility to review complex content as needed, which

leads to a more comprehensive understanding. The ability to pause, replay, and re-engage with the material promotes self-paced learning and clarity. Additionally, the visually engaging format helps maintain students' interest, contributing to a supportive environment that inspires continuous learning and fosters a sense of accomplishment.

4. Fostering Higher-Order Thinking Skills: The structure of answering challenging questions and engaging in problem-solving promotes critical and evaluative thinking. This interaction with complex questions and immersive media helps students articulate their learning systematically. Students develop skills in summarizing, analyzing, and structuring their responses, which contributes to a deeper understanding of the subject matter.

The implementation of the 5-step IBL model, alongside YouTube-based lessons, successfully merges independent exploration, technology-driven engagement, and guided mentorship to enhance student-centered learning outcomes. The study's findings indicate that this approach not only boosts content comprehension but also cultivates critical thinking, collaborative skills, and a positive mindset toward lifelong learning. This approach provides a solid foundation for fostering independent learners who are well-equipped for analytical thinking and continuous knowledge acquisition.

Conclusions

In summary, the study on the 5-step Inquiry-Based Learning (IBL) approach with online lessons on YouTube for "Coal and Petroleum" yielded the following key findings:

1 . **Efficiency**: The 5-step IBL approach achieved an E1/E2 efficiency score of 82.50/81.38, exceeding the target criterion of 80/80.

2. **Learning Achievement**: Students' achievement scores significantly improved after learning through the 5-step IBL approach, indicating a notable increase in academic performance.

3. **Learner Satisfaction**: The satisfaction level among students reached a mean score of 4.23, signifying a high level of satisfaction with the learning experience.

These findings suggest that the 5-step IBL approach with online lessons on YouTube for "Coal and Petroleum" is an effective and engaging instructional method, meeting or exceeding the established benchmarks for efficiency, academic achievement, and student satisfaction.

Suggestions

Based on the study of the 5-step Inquiry-Based Learning (IBL) approach with online lessons on YouTube for "Coal and Petroleum," the following recommendations are suggested:

1. **Utilization of YouTube for Teaching and Learning**: YouTube can effectively serve as a platform to manage and organize diverse teaching media, including content, instructional videos, and other learning resources. This setup allows students to review lessons anytime, anywhere, which helps to minimize differences in learning pace and retention among learners.

2. **Support for Internet Access and Technology**: Since access to online lessons on YouTube requires an internet connection via devices such as laptops or mobile phones, it is essential for parents and educational institutions to provide financial and technological support. Ensuring access to adequate computers and a stable internet connection is crucial for equitable learning opportunities.

3. **Exploration of Diverse Educational Technologies**: It is recommended to investigate the integration of various technologies alongside traditional and alternative teaching methods. Offering a range of options will increase student engagement and interest, enhancing their learning experience across subjects.

These recommendations aim to optimize the use of online learning platforms, address access challenges, and explore innovative teaching methods to enrich educational experiences.

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