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The Design of a Liquid Pressure Gauge to Enhance Conceptual Understanding of Fluid Pressure

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Abstract−This research aimed to: 1) design and develop a liquid pressure gauge learning module, and 2) improve students' conceptual understanding of pressure in liquids. The study began with an investigation of students' prior conceptions and misconceptions regarding liquid pressure. A set of diagnostic questions was developed and administered to explore students' understanding of key pressure concepts. The findings indicated several misconceptions, including the belief that liquid pressure depends on the size and shape of the container and that liquids with lower density will always remain at the top surface. Based on these findings, a liquid pressure learning module was designed and developed. The module consisted of a conceptual understanding test, instructional materials, and lesson plans based on the Interactive Learning Demonstration (ILD) approach. The learning module was implemented with six students from Trat Polytechnic College. Its effectiveness was evaluated through assessments of students' conceptual understanding and learning expectations. The results showed a statistically significant improvement in students' understanding at the 0.05 level. The average normalized gain (g) was 0.55, indicating a moderate level of learning improvement and suggesting that the ILD-based learning module is suitable for enhancing physics instruction.

Keywords: Learning Module; Interactive Learning Demonstration; Normalized Gain; The Demonstration of Liquid Kid; Gauge Pressure

1. INTRODUCTION

Fluid mechanics is a scientific discipline that studies the behavior and properties of fluids, including important concepts such as pressure, density, and fluid motion. the subject requires students to integrate knowledge of physics with mathematical calculations in order to understand theoretical principles and solve practical problems effectively [1]. In vocational and science education, fluid mechanics plays a significant role because it provides fundamental knowledge that can be applied in engineering, industrial technology, and everyday life. However, despite its importance, many students still experience difficulties in understanding fluid mechanics concepts, especially those related to fluid pressure and density.

At present, the instructional methods commonly used in classrooms are still focused on teacher-centered lectures. In this traditional approach, teachers mainly deliver theoretical content while students passively receive information. As a result, many learners are unable to fully understand the concepts being taught and often have limited opportunities to participate actively in classroom activities [2]. The lack of interaction and hands-on experience prevents students from developing deep conceptual understanding. Consequently, students' academic achievement and learning outcomes in fluid mechanics are often unsatisfactory [3].

One of the major causes of this problem is that many learners rely primarily on rote memorization rather than conceptual understanding. Students tend to memorize formulas and procedures without understanding the underlying physical principles or learning how to apply the knowledge creatively in real-world situations [4]. This learning behavior limits students' analytical thinking, problem-solving ability, and scientific reasoning skills. Moreover, students may develop misconceptions about fluid mechanics concepts because they cannot visualize or observe the actual phenomena being discussed in the classroom.

Therefore, it is necessary to develop new instructional approaches that can improve students' understanding and encourage active participation in the learning process. Effective teaching methods should support learners in developing not only academic knowledge but also analytical thinking skills, scientific process skills, and positive attitudes toward learning. Modern education emphasizes student-centered learning environments in which learners can interact with instructional materials, participate in classroom activities, and construct knowledge through direct experience. For this reason, teachers in the present educational era face the challenge of designing innovative instructional methods and learning activities that enable students to observe, explore, and understand fluid mechanics concepts in a concrete and meaningful way.

The effectiveness of instructional methods can be evaluated through students' learning achievement and conceptual development. One important indicator widely used in educational research is the normalized gain, which measures the improvement in students' understanding before and after instruction [5]. The normalized gain can reflect how effectively instructional activities help students improve their conceptual understanding. Therefore, teachers must carefully design learning activities, course content, and instructional media, including the development of appropriate experimental equipment and teaching materials that can effectively support classroom learning [6].

Fluid mechanics is a topic of particular interest to the researcher because of extensive teaching experience in this subject over several years. Through classroom observations and teaching practice, the researcher found that many students have misconceptions and incomplete understanding regarding fluid pressure concepts. Students often struggle to understand the relationships between pressure, density, and liquid behavior because these concepts are abstract and difficult to visualize through theoretical explanation alone. This issue motivated the researcher to develop innovative teaching methods and instructional tools to improve students' conceptual understanding.

To investigate students' misconceptions, the researcher collected data from a sample group of six students who had previously studied fluid pressure concepts. The students were asked to complete a seven-item multiple-choice conceptual test and provide explanations for their answers. The findings revealed that most students demonstrated misconceptions and misunderstandings related to fluid pressure and fluid density. These results confirmed that traditional lecture-based instruction was insufficient for promoting deep conceptual understanding.

In response to these problems, the researcher designed and developed a learning package based on Interactive Learning Demonstration (ILD) techniques [7]. The instructional package consisted of several experimental learning activities, including a fluid pressure experiment, an experiment comparing fluid pressure under different liquid densities, and an experiment comparing the densities of various liquids using a manometer tube. These activities were designed to provide students with opportunities to observe real phenomena, make predictions, discuss results, and interact directly with experimental equipment.

The use of Interactive Learning Demonstration was intended to increase student participation and engagement in classroom learning. By observing actual demonstrations and participating in hands-on activities, students could connect theoretical concepts with real experimental evidence. This approach was expected to help students develop more accurate conceptual understanding and reduce misconceptions regarding fluid pressure and density. Furthermore, the learning activities encouraged students to think critically, analyze experimental results, and apply scientific reasoning during the learning process.

After implementing the instructional activities, the researcher analyzed students' conceptual understanding through pre-test and post-test assessments. The results were used to evaluate the effectiveness of the learning package and determine students' learning progress. The researcher believes that the developed instructional activities and experimental learning tools can significantly improve students' understanding of fluid mechanics concepts, enhance learning achievement, and promote positive attitudes toward science learning [8].

2. RESEARCH METHODS

2.1 Basic Research Framework

This research is quantitative and the learning module including a demonstration of liquid manometer Interactive Learning Demonstration (ILD) and Quiz the methodology is presented in the following diagram.

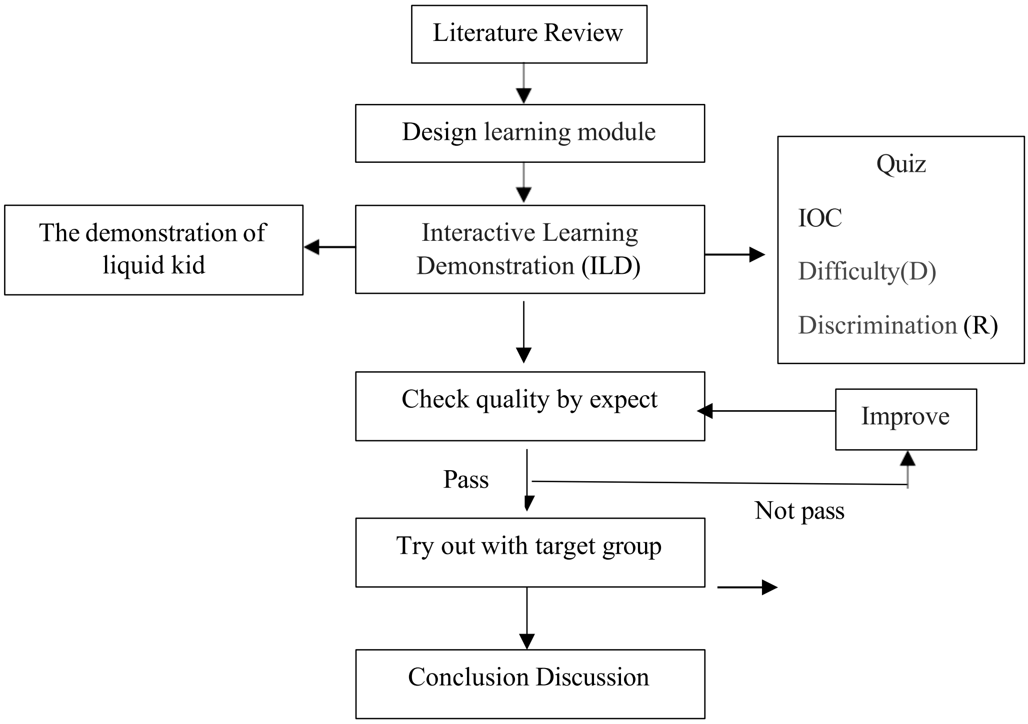

Figure 1. Research Methods

2.2 Research Objective

a. To design a learning module.
b. To develop students' understanding by interactive demonstration learning (ILD).

2.3 Scope of the Research

a. Content Scope
   This research focuses on the development and implementation of a liquid pressure learning module designed to enhance students' conceptual understanding of fluid pressure. The instructional content covers the fundamental principles of hydrostatic pressure, the relationship between pressure and liquid depth, the effects of liquid density on pressure, and the application of pressure measurement using a pressure gauge. The learning activities are conducted using the Interactive Lecture Demonstration (ILD) instructional approach.
b. Population/Sample Scope
   The population/ Sample Scope of this study consists of 6 students from Electronic department Trat Polytechnic College who are studying the topic of fluid pressure during the academic semester in which the study is conducted.
c. Geographical Scope
   The study is conducted at Trat Polytechnic College Thailand. The research setting includes classrooms and laboratories where the learning module is implemented and evaluated.
d. Time Scope
   The research is conducted during the first semester of the 2025 academic year.

2.3 Hypothesis

Students who learn using the learning module integrated with Interactive Lecture Demonstrations (ILD) demonstrate significantly higher post-test scores in conceptual understanding of fluid pressure than pre-test scores at the .05 level of significance. The normalized gain (g) of students' conceptual understanding after learning with the liquid pressure gauge learning kit is at a medium or high level.

2.4 Conceptual Framework

Independent Variable (IV)
Learning module
- The demonstration of liquid manometer
- Interactive Learning Demonstration (ILD)
- Quiz

→

Dependent Variable (DV)
The normalized gain

Figure 2. Conceptual Framework

3. RESULTS AND DISCUSSION

There are three learning objectives consisting of
a. The concept of pressure when the size of a tube changes.
b. The concept of pressure when the density of a liquid changes.
c. The densities of various liquids in a tube.

Figure 3 The demonstration of liquid kid
(For learning objectives a. and b.)

Figure 4 The demonstration of liquid kid
(For learning objectives c.)

Figures 5 and 6 show that, for Learning Objective 1, students were able to correctly answer only 39.81% of the pre-test questions. However, after study with learning module the post-test score increased to 82.41%. The students' learning gain was calculated at 0.71, which is considered a high level of learning progress (gain score ≥ 0.7).

For Learning Objective 2, students correctly answered only 16.67% of the pre-test questions. After study with learning module, the post-test score increased to 61.11%. The calculated learning gain was 0.53, indicating a moderate level of learning progress (gain score ≥ 0.3).

For Learning Objective 3, students correctly answered only 39.26% of the pre-test questions. After study with learning module, the post-test score increased to 70.00%. The calculated learning gain was 0.51, which is also categorized

Vol 1, No 1, June 2026, Page 432-437
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as a moderate level of learning progress (gain score ≥ 0.3).

These findings indicate that the learning module using Interactive Demonstration learning activities effectively improved students' learning and understanding.

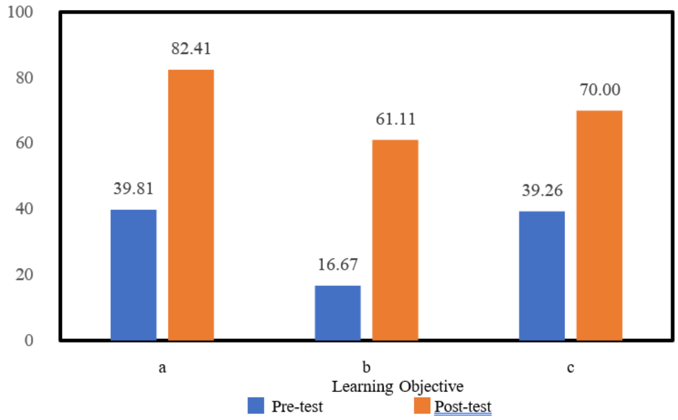

Figure 5. The percentile compare between pre – post test for each learning objective

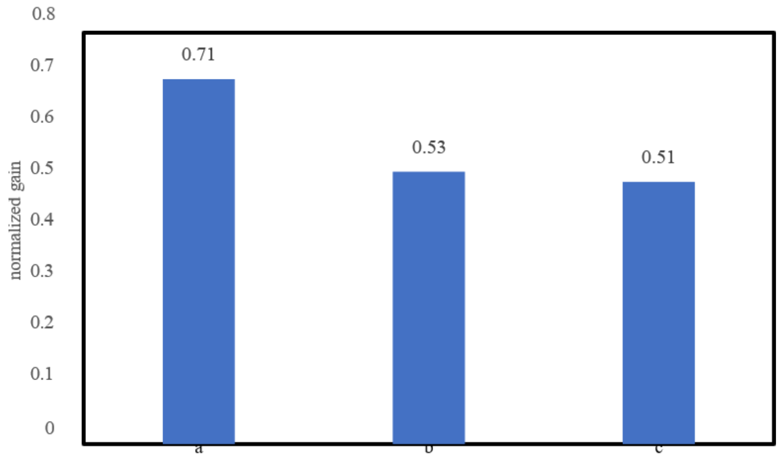

Figure 6. The normalized gain for each learning objective

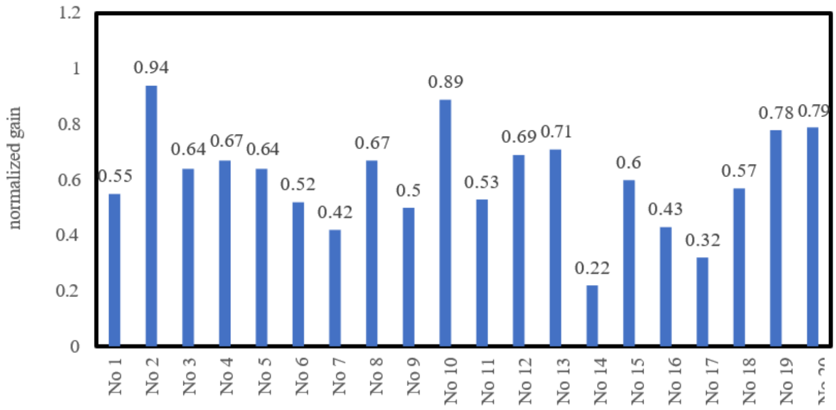

Figure 7. The normalized gain for each quiz.

Figure 7 shows that students demonstrated improved learning development at a high level in four test items: Questions 2, 11, 14, and 20, accounting for 20% of the total test items when considering each item individually, Question 2 showed a learning gain of 0.94, which is categorized as a high level of learning progress (gain score ≥ 0.7). The percentage of students who answered the question correctly before instruction was 33.33%, while the percentage increased to 96.3% after instruction.

These results indicate that the learning package on pressure measurement in fluids, implemented through the Interactive Demonstration learning approach, was effective in enhancing students' learning development and understanding. The characteristics of Question 2 are illustrated in Figure 8

Vol 1, No 1, June 2026, Page 432-437
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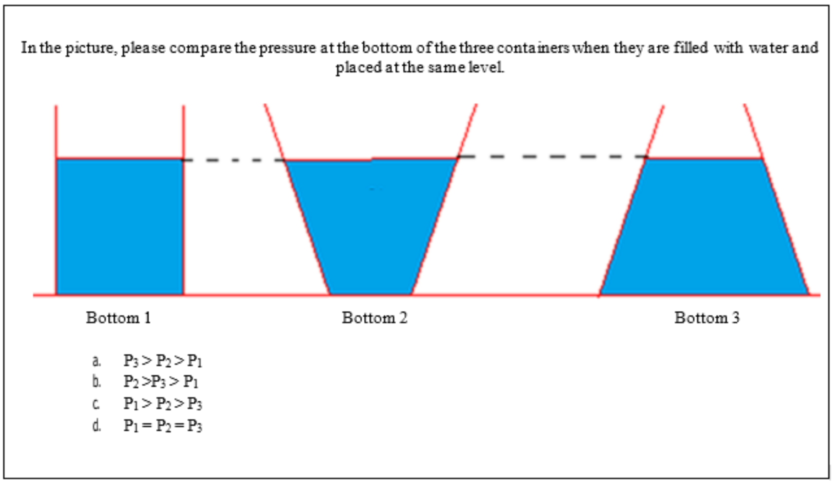

Figure 8. Question No.2

Table 1. The normalized gain after learning by ILD module

Result	Average Score	S.D.	Normalize gain <g>
Pre-test	6.52	2.03	0.55
Post-test	13.96	2.33	

Table 1 presents a comparison between the pre-test and post-test conceptual understanding scores of six students. The results show that the mean pre-test score was 6.52 (S.D. = 2.03), while the mean post-test score increased to 13.96 (S.D. = 2.33). The normalized learning gain was 0.55, indicating a moderate level of learning improvement. suggesting that the post-test scores were significantly higher than the pre-test scores at the .05 level of significance.

3.1 Discussion

a. Components should be constructed from readily available and low-cost materials to ensure practicality and ease of use for both learners and instructors.
b. Since the apparatus is designed with detachable and replaceable components, users are advised to study the operation and maintenance procedures provided in the user manual to prevent damage to the equipment and to ensure its proper functionality.
c. To enhance instructional effectiveness teaching and learning activities should be conducted with the assistance of a co-teacher or teaching assistant this is because the main instructor is required to focus primarily on demonstrating and explaining the experiments which may cause delays if simultaneous equipment preparation and demonstration are required.

4. CONCLUSION

The researcher conducted a diagnostic assessment of students' understanding after they had previously studied the topic of fluid pressure and found that the students still held several misconceptions. Consequently, the researcher designed a fluid pressure learning module, which consisted of several experimental sets, including: (1) The concept of pressure when the size of a tube changes, (2) The concept of pressure when the density of a liquid changes (3) The densities of various liquids in a tube, as well as an interactive lecture demonstration (ILD) learning management plan, worksheets, and activity sheets. These instructional materials were designed to engage students in hands-on learning activities in order to develop conceptual understanding in three concepts consist of (1) liquid pressure in relation to tube size, (2) liquid pressure in relation to fluid density, and (3) comparison of densities of various liquids in a tube.The efficiency evaluation of the developed learning module revealed an error range between 1.96% and 6.67% compared to theoretical calculations, indicating that the apparatus was sufficiently accurate and suitable for instructional use. In addition, the researcher developed a conceptual understanding test aligned with specific learning objectives. The test was validated by experts to determine the index of item-objective congruence (IOC), as well as item difficulty and discrimination indices. The learning module was implemented with a sample group consisting of six students from Trat Polytechnic College. The results indicated that students' conceptual understanding improved significantly at the 0.05 level of statistical significance. The average normalized learning gain was 0.55, which is interpreted as a moderate level of improvement. Furthermore, analysis of students' responses revealed that the percentage of misconceptions in each conceptual area decreased after the learning intervention. These findings suggest that learner-centered instructional approaches, which encourage students to express ideas, engage in discussion, and exchange knowledge, combined with the use of hands-on demonstration apparatus, have a strong positive impact on conceptual understanding. Overall, the interactive lecture demonstration approach employed in this study effectively enhanced students' academic achievement and conceptual understanding, indicating that active participation in classroom learning alongside experimental demonstration tools leads to a significantly improved level of comprehension.

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