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# Stoichiometry understanding of upper secondary students through active science learning

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**ABSTRACT**

The goals of the study were as follows: i) to design an active science learning activity on stoichiometry for grade 10 students, ii) to evaluate the academic achievement of grade 10 students after receiving an active science learning activity on stoichiometry, and iii) to investigate the perspectives of grade 10 students regarding an active science learning activity on stoichiometry. The research utilized a sample group consisting of 41 students who were enrolled in the tenth grade during the second semester of the academic year 2022. The research tools provided participants with active science learning lessons. A test of the kids' academic prowess as well as their thoughts on the use of hands-on scientific learning activities will be administered. The mean, the standard deviation, and a one-sample t-test were the types of statistics that were utilized in the investigation. The following is an outline of what the research found: i) the appropriateness of the active science learning activities was judged to be the highest level, ii) the academic achievement of grade 10 students after receiving the active science learning activities on stoichiometry had an average score that was higher than the criteria of 70% with a statistical significance at the .05 level; and iii) the opinions of students on the implementation of active science learning activities on stoichiometry were in the agree level.



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## 1. INTRODUCTION

Education is a necessary instrument for the formation of individuals as well as societies and nations [1]–[3]. It is the primary means through which a high-quality labor force may be developed. ability to coexist peacefully with other members of society despite the turbulence and uncertainty that characterize life in the 21st century [4], [5]. Teachers should be able to manage particular learning content in a way that is responsive to the various learning processes that learners engage in by selecting suitable technology as an essential instrument in the management of learning. The combination of three facets of knowledge, namely content knowledge, teaching techniques, and technology, is known as the knowledge of teaching methods and technology. educating students in both general and specialized information [6], [7]. The term "content knowledge" refers to factual content knowledge as well as principal concepts, theories, principles, and practices, as well as the nature of knowledge and the nature of the quest for information in certain topic areas [8], [9].

The information and communication can be learned through effective instruction, the learning achievement can be grown by participation and democratic classroom. That is, science is both content and process allow students to understanding about how to live with active participation [10], [11]. The study of the composition, structure, and characteristics of substances, as well as their transformations, falls under the purview of the scientific discipline known as chemistry [12]. Classification, performing chemical operations, and thinking in terms of chemical processes are all effective ways to increase one’s chemistry knowledge. Chemists organize items, substances, or phenomena into categories that make it simpler for researchers to examine them. as well as the division of the elements into periods and groups in the periodic table, according to the physical and chemical characteristics of the elements.

In addition, in order to gain an understanding of the characteristics and reactions of various substances, chemists carry out experiments. These experiments may include determining the temperature at which water boils or melts, for example. The process of using images or models to represent an explanation and a prediction of the behavior of substances at the particle level is referred to as chemical thinking. The study of matter and the transformation of matter into other forms may be accomplished by classification, experimentation, and critical thinking in chemistry. Students are required to grasp and explain observable changes at the atomic, molecular, or atomic level. Furthermore, students are expected to communicate using chemical formulae, chemical equations, or processes in reactions, among other things [13].

According to the findings of the researcher, learning management was noticed in the chemistry class during the previous semester. Students in the 10$^{th}$ grade in science and technology learning group discovered that the majority of learners had little comprehension of the material covered in the course. At the junior high school level, students are exposed to a substantial amount of scientific foundation material, resulting in a decrease in the effectiveness of the learning process. The fundamental aspects of chemistry might be challenging for students. and had a comparatively low level of success in chemistry-related disciplines. Which may be seen from the scores from the exam for each purpose, the midterm test, or the test at the end of the semester, results in scores that are not adequate. Students’ less comprehension of the fundamental concepts underlying chemistry may be one of the causes behind this.

In addition, the present learning management places an emphasis on teaching and lectures, and it strongly recommends that students memorize information from books or other written sources of information. instead of giving the pupils the opportunity to practice. demonstrate a genuine and enthusiastic interest in learning management. It is evident from the accomplishment scores as well as the results of the numerous knowledge assessments. This means that the average score at the school is lower than the average score at the national level. Another reason is that the COVID-19 epidemic, which had a wide-ranging impact, particularly on a group of students who must be developed in various fields, both academically and emotionally and socially, must be stopped. As a consequence of this, students had trouble accessing various learning materials during the early stages of the COVID-19 outbreak. Because of this, many students who are not yet prepared to withdraw from their distance education programs are unable to satisfy the specific educational requirements of individual pupils. Another aspect of the issue that the phenomenon known as learning loss or learning recession [14]–[16]. This situation emerged as a consequence of constraints placed on the economic standing of households, which led to a reduction in the access that students had to educational opportunities. That is, students who have access to online learning resources often feel obligated to spend too much time in front of the computer or find that they have less time to spend with their friends [17]–[19]. There is no interaction with other people at all, which results in a condition known as full brain or may impact the mind through stress or anxiety, leading to a state of depression [20], [21].

Therefore, the researcher presented the data and its many features to evaluate and synthesize in order to create a technique to manage learning that focuses on the ability of the learners to really comprehend the information. The researcher explored and researched facts to remedy instructional misunderstandings. nature of the course and how regress influences academic progress from textbooks, publications, and relevant studies. A learning management strategy develops knowledge, skills, and desired traits. The study indicated that learning management can help students develop critical thinking skills. Active science learning management creates new knowledge [22]. It promotes cooperative work in learning, discuss to create new knowledge, and measure and evaluate according to current situations. Learning activities must include reading, writing, conversing, and problem-solving [23]. Students can employ higher thinking skills, including analysis, synthesis, and value [24], [25].

Therefore, in order to create a dynamic science learning activity on stoichiometry for 10$^{th}$ graders. The researchers employs this learning management in order to cultivate active science learning activities, Comparison of the learning outcomes attained after implementing active science learning activities and the students’ perspectives on these activities. This learning management emphasizes students’ development of their own thought processes. Inspiring interest in the course through student-centered, teacher-as-supporter or adviser actions. Enhance knowledge and comprehension that students can actively use in their daily lives and that can be developed further in the future, both for studying and working.

## 2. RESEARCH METHOD

This research employed experimental design. The procedure and conduction can be described as, the population used in this study were grade 10 students in the science-mathematics learning program, semester 2, academic year 2022, Roi Et Wittayalai School. Roi Et Secondary Educational Service Area Office, 5 rooms, 199 students. The sample group used in the research was 41 students in grade 10, the second semester of the academic year 2022, with a total of 41 students obtained by cluster random sampling. According to the basic education core curriculum 2008 (Revised 2017) unit 6 on stoichiometry consisting of stories chemical reactions, chemical equations, calculating the number of substances in a chemical reaction dosing agent and percentage. The data were collected in semester 2, Academic year 2022, using experimental time of 3 hours per week, totaling 5 weeks, totaling 15 hours [26].

Research tools used in research consisted of active science learning activities with 10 lesson plans on stoichiometry. Achievement test for assessing the student's achievement which has been organized with proactive learning activities, is a multiple-choice type, with a total of 30 items, 4 scaling self-assessment, and perspective questionnaire on the management of active science learning activities. It is a 5-level estimation scale with 15 items. Data were collected through the time of experiment when the teaching and learning has been completed according to the active science learning management. The researchers conducted a post-test to measure learning achievement compared to the 70% criteria by using the learning achievement test on stoichiometry. Then bring it to check and score and record it as a test score after class. It was analyzed to find out objective of the study by employing the mean, standard deviation, and one sample t-test to compare achievement.

After putting together hands-on scientific learning activities and evaluating their overall academic performance. The information about perspective on the learning activities were gathered by a questionnaire to collect responses from individuals on their perspectives on active scientific learning activities, the compiled responses were then subjected to statistical analysis to determine the mean, standard deviation, and overall findings of the study. Data were analyzed by bringing the created learning activities to 5 experts to consider and review the activities. By using rating scale method according to the method of Likert (Likert) 5 levels, then analyzing the statistical data by finding the mean and standard deviation.

## 3. RESULTS AND DISCUSSION

From the study of the development of active science learning activities achievement and the opinions of the students after receiving an active science learning activity on stoichiometry of grade 10 students can be summarized as follows: first, active science learning management activities development: It was found that the appropriateness of the active science learning activities. In each step of learning management, indicating that the development of active science learning activities was the most appropriate. It is accepted and can be used in learning activities as shown in Table 1. From Table 1, it was found that the appropriateness of the active science learning activities in each step of learning management was at highest level. The average fitness was 4.55 and the standard deviation was 0.56, indicating that the development of active science learning activities was the most appropriate. It is accepted and can be used in learning activities. The results of the analysis of the appropriateness of the active science learning activities on stoichiometry of grade 10 students found that active science learning activities were appropriate for learning activities. The investigation into whether active learning activities in science are appropriate for tenth-grade students studying stoichiometry reveals that these activities enhance the educational opportunities available to students [27]. Learning activities provide an appropriate framework for the instruction of stoichiometry because they emphasize learning by doing, resulting in greater conceptual comprehension, collaboration, and student motivation [28]. In order for students to acquire a deeper understanding of stoichiometry concepts and retain them for a longer period of time, instructors should seriously consider incorporating the strategies described here into their instructional practices. Participating actively in the learning process and actively engaging with the material enables students to acquire vital scientific skills and achieve greater success in their scientific endeavors.

The study of the quantitative connections that exist in chemical reactions between the reactants and the products is known as stoichiometry. Stoichiometry is an essential subject in the field of chemistry. Active science learning activities have recently garnered a lot of attention from educators, who are working hard to improve their students' educational experiences. During the course of this conversation, we are going to investigate the findings of a study that evaluated the suitability of active scientific learning activities for students in grade 10 who are studying stoichiometry [29]. Students are encouraged to participate in hands-on, inquiry-based learning experiences through the use of active scientific learning activities, which are pedagogical techniques. Participation in these activities, as well as student cooperation, critical thinking, and the development of problem-solving abilities, are all encouraged [30]. Students have the ability to improve their overall learning outcomes and deepen their grasp of scientific topics when they participate actively in the learning process.

Table 1. Appropriateness of active science learning activities

| Item | $\bar{x}$ | SD | Appropriateness |
|---|---|---|---|
| Stage 1: Stimulating prior knowledge | | | |
| 1.1. Learning activities are appropriate to the learning objectives. | 4.40 | 0.55 | High |
| 1.2. Learning activities are appropriate to the content. | 4.60 | 0.89 | Highest |
| 1.3. Learning activities are appropriate for assessment. | 4.40 | 0.55 | High |
| 1.4. The learning activities were based on the principles of science learning activities using an active science teaching model. | 4.60 | 0.55 | Highest |
| 1.5. Learning activities are diverse. | 4.60 | 0.55 | Highest |
| 1.6. Appropriateness of time spent on activities | 4.40 | 0.55 | High |
| Stage 2: Find and summarize information | | | |
| 2.1. Learning activities are appropriate to the learning objectives. | 4.40 | 0.55 | High |
| 2.2. Learning activities are appropriate to the content. | 4.60 | 0.55 | Highest |
| 2.3. Learning activities are appropriate for assessment. | 4.60 | 0.55 | Highest |
| 2.4. The learning activities were based on the principles of science learning activities using an active science teaching model. | 4.60 | 0.55 | Highest |
| 2.5. Learning activities are diverse. | 4.60 | 0.55 | Highest |
| 2.6. Appropriateness of time spent on activities | 4.60 | 0.55 | Highest |
| Stage 3: Knowledge creation and application | | | |
| 3.1. Learning activities are appropriate to the learning objectives. | 4.60 | 0.55 | Highest |
| 3.2. Learning activities are appropriate to the content. | 4.80 | 0.45 | Highest |
| 3.3. Learning activities are appropriate for assessment. | 4.60 | 0.55 | Highest |
| 3.4. The learning activities were based on the principles of science learning activities using an active science teaching model. | 4.40 | 0.55 | High |
| 3.5. Learning activities are diverse. | 4.60 | 0.55 | Highest |
| 3.6. Appropriateness of time spent on activities | 4.40 | 0.55 | High |
| Overall | 4.55 | 0.56 | Highest |

Second, learning achievements after organizing an active science learning activity on stoichiometry of grade 10 students with the criteria of 70%, it was found that of all 41 students, there were 35 students who got the test score after passing the criteria of 70% representing 85.36% of all students. There were 6 students who did not pass the exam with a score of 70%, representing 14.64% of all students. and a comparison of learning achievements after receiving active science learning activities on stoichiometry of grade 10 students had an average score higher than the criteria of 70% with a statistical significance at the .05 level as shown in Table 2.

Table 2. Learning achievements of grade 10 students

| Test | n | k | 70% | $\bar{x}$ | SD | t | Sig. |
|---|---|---|---|---|---|---|---|
| Post-test | 41 | 30 | 21 | 24.73 | 3.30 | 7.237 | .000 |

*It was statistically significant at the .05 level.

From Table 2, it was found that the learning achievement after receiving the active science learning activity on stoichiometry of grade 10 students had an average score higher than the criteria of 70% with a statistical significance at the .05 level. The results showed that learning achievement on stoichiometry of grade 10 students had an average score higher than the criteria of 70% with a statistical significance at the .05 level. This was due to the active science learning activities can gain their level of understanding. It is a teaching and learning management that focuses on encouraging students to find answers by themselves. There are steps to find answers from easy to difficult, from abstract to concrete, from the foregoing. This makes teaching more efficient and results in higher student achievement. The research results showed that the students who received active learning had average scores higher than those of students who received regular learning. The students in the experimental group had learning achievement in chemistry on stoichiometry significantly higher than before learning at the .05 level and significantly higher than pretest at the .05 level.

This result indicates that the implementation of active science learning activities improved students' understanding of stoichiometry. The statistical analysis, conducted at the 0.05 significance level, implies a robust and reliable enhancement in the experimental group's learning achievement. In addition, the posttest scores of the experimental group were found to be significantly higher than those of the criterion. This finding suggests that active scientific learning activities resulted in a larger improvement in achievement. The results of this investigation demonstrate the positive influence of active science learning activities on students' stoichiometry learning achievement [31]. By engaging students in hands-on experiences, fostering collaboration, and encouraging critical thinking, active science learning activities create an interactive and dynamic learning environment that facilitates a deeper understanding of and greater retention of concepts [32].

Active science learning activities allow students to investigate stoichiometry concepts in a practical and experiential manner, thereby enhancing their conceptual understanding. Students acquire a deeper understanding of quantitative relationships in chemical reactions through hands-on experiments and problem-solving assignments. This enhanced conceptual comprehension results in enhanced assessment performance [33]. Active science learning activities increase student engagement and motivation by making stoichiometry teachings more relevant and interactive. Participating actively in the learning process, as opposed to passively receiving information, increases students' interest and enthusiasm for the subject. This increased engagement can have a positive effect on learning outcomes [34].

Third, opinions on organizing an active science learning activity on stoichiometry of grade 10 students were at the agree level with a mean score of 4.43 and a standard deviation of 0.68. The opinions were at the level of strong agreement for 5 items: i) active science learning activities that allowed everyone to participate in learning, ii) teacher explained the tasks which students must clearly, iii) teachers presented interesting new lessons, iv) teacher gave the opportunity for the students to summarize the lessons themselves, and v) students used the data obtained from the observation record to explain with reason, and comments on other items in agreeing level. The details can be shown in Table 3.

From Table 3, it was found that the opinions of the students towards the active science learning activities on stoichiometry of grade 10 students were at the agree level. Teachers have presented new lessons to make students interesting, eager to learn, as well as giving students the opportunity to participate in learning activities with classmates and teachers. The learning management make learning fun and when considering individually, it was found that the opinions were at the level of strong agreement [35], [36].

Students are given the opportunity to study at their own learning progress and in a manner that is tailored to their own interests, Active learning involves both of these aspects. Students have the ability to access information and complete assignments using a variety of devices from any location at any time. Students may pick the learning activities and materials that match their interests and learning styles when they have the option to customize their educational experiences, which boosts their engagement and pleasure in the educational process [37], [38]. However, the study has general recommendations for development of active science learning activities, its emphasis on students to get into real action, gather information, and interact with others. Teachers must advise, recommend, and ask questions to encourage students. Time spent on active science learning activities should be considered that it may be flexible according to atmospheric conditions. and potential of learners and most importantly, it should be developed continuously [39].

Table 3. Perspective of grade 10 students towards active science learning

| | Item | $\bar{x}$ | S.D. | Perspective |
|---|---|---|---|---|
| | Learning activities | | | |
| 1. | Organizing active science learning activities that allow everyone to participate in learning. | 4.59 | 0.80 | Strongly agree |
| 2. | Organizing active science learning activities with practical activities in every activity. | 4.29 | 0.73 | Agree |
| 3. | Organizing active science learning activities to exchange knowledge with each other. | 4.44 | 0.70 | Agree |
| 4. | Organization of active science learning activities makes learning fun. enhancing the learning atmosphere | 4.49 | 0.67 | Agree |
| 5. | Organizing active science learning activities leads to joint planning in the group. | 4.41 | 0.70 | Agree |
| | Teacher role | | | |
| 1. | The teacher clarified the tasks. which students must clearly follow | 4.68 | 0.47 | Strongly agree |
| 2. | Teachers present interesting new lessons. | 4.51 | 0.64 | Strongly agree |
| 3. | The teacher always asks questions for the students to think about. | 4.39 | 0.67 | Agree |
| 4. | The teacher gives students the opportunity to summarize the lesson by themselves. | 4.56 | 0.63 | Strongly agree |
| 5. | Teachers use appropriate teaching techniques. | 4.41 | 0.77 | Agree |
| | Student role | | | |
| 1. | Students participated in activities. help each other think together | 4.24 | 0.66 | Agree |
| 2. | Students discuss and express their opinions together. | 4.05 | 0.74 | Agree |
| 3. | Students accept each other's opinions. | 4.39 | 0.74 | Agree |
| 4. | Students express their opinions freely but within the scope of the activity. | 4.39 | 0.70 | Agree |
| 5. | Students rationally use the information obtained from the observation record to annotate. | 4.59 | 0.59 | Strongly agree |
| | Overall | 4.43 | 0.68 | Agree |

## 4. CONCLUSION

The following is an outline of what the research found that active science learning activities was judged to be the highest level of appropriateness, the academic achievement of students after exposing the active science learning activities on stoichiometry had an average score that was higher than the criteria of

70%, and the opinions of students on the implementation of active science learning activities on stoichiometry were in the agree level. However, the study required more studied in the diverse tools and methods to use for variety of learning styles and online learning behavior. Students agreed with active science learning exercises on stoichiometry, teachers have introduced new classes and allowed them to work with classmates and teachers. Active learning lets students' study at their own pace and according to their interests. Students can use several devices to access and complete assignments from anywhere. According to the study, active science learning activities should encourage students to take action, obtain information, and communicate with others. For student encouragement, teachers must advise, recommend, and ask questions.

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