

Development and Evaluation of a Patintero-Based Learning Approach for Teaching Balancing Chemical Equations

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ABSTRACT

Balancing chemical equations is a fundamental chemistry competency that can be challenging for learners because it requires understanding the law of conservation of mass and the proper use of coefficients and chemical formulas. To address this challenge, this study developed and evaluated a Patintero-Based Learning Approach for Teaching Balancing Chemical Equations. The study employed a quasi-experimental research design involving fifty-seven (57) Grade 10 learners from a private school in Iligan City during in the School Year 2025–2026. Twenty-eight (28) learners comprised the control group, while twenty-nine (29) comprised the experimental group. The control group received conventional instruction, whereas the experimental group was taught using the Patintero-Based Learning Approach. Data were collected through a researcher-developed Balancing Chemical Equations Test and a perception questionnaire. The reliability of the pretest was established using Cronbach's alpha, which yielded 0.73, while the perception questionnaire yielded 0.74, indicating acceptable internal consistency. Descriptive statistics were used to summarize the data, while the Mann–Whitney U test was employed to determine whether a significant difference existed between the performance of the two independent groups. Results revealed a statistically significant difference between the groups ($U = 11.500$, $Z = -6.311$, $p < .001$), with the experimental group obtaining higher performance than the control group. The learners also expressed a strongly positive perception of the Patintero-Based Learning Approach, obtaining a grand mean of 3.48, interpreted as Strongly Agree. The findings indicate that integrating a familiar traditional Filipino game into chemistry instruction can provide an engaging and meaningful learning experience while supporting learners' understanding of balancing chemical equations. The study recommends the use of the approach as a supplementary strategy for promoting active participation, collaboration, and problem-solving in chemistry learning.

Keywords: Patintero-Based Learning Approach, balancing chemical equations

INTRODUCTION

Chemistry plays a vital role in science education by enabling learners to understand the composition, properties, and transformations of matter. As a central discipline in science, chemistry equips learners with the knowledge and skills needed to explain natural phenomena, solve real-world problems, and make informed decisions about issues related to health, industry, technology, and the environment. Among the fundamental competencies in chemistry, balancing chemical equations is particularly important because it provides the foundation for understanding the law of conservation of mass, stoichiometry, and the quantitative relationships among reactants and products in chemical reactions. Developing proficiency in this competency allows learners to interpret chemical processes accurately and prepares them for more advanced chemistry concepts by Taber (2013) [5] and Talanquer (2011) [6].

Despite its importance, balancing chemical equations has consistently been identified as one of the most challenging topics for learners. Many learners struggle to interpret chemical formulas, apply the law of conservation of mass, and distinguish between coefficients and subscripts, often relying on trial-and-error rather than conceptual reasoning by Taber (2013) [5]. These learning difficulties contribute to persistent misconceptions and poor performance in chemistry. Furthermore, the Programme for International Student

Assessment (PISA) 2022 reported that many learners continue to demonstrate low levels of scientific literacy and problem-solving skills, highlighting the need for more engaging and learner-centered instructional approaches (OECD, 2023). In the Philippine context, the Department of Education has emphasized contextualized and learner-centered instruction through the MATATAG Curriculum to improve learning outcomes and make science education more relevant to learners' experiences (Department of Education, 2023) [2].

To address these challenges, game-based learning has emerged as an effective instructional approach that promotes active participation, collaboration, critical thinking, and meaningful learning. By integrating educational objectives with structured game activities, game-based learning creates an engaging classroom environment where learners actively construct knowledge rather than passively receive information. Plass et al., (2015) [4] explained that well-designed educational games enhance learner engagement by aligning instructional objectives with meaningful gameplay. Likewise, Boyle et al., (2016) [1] found that game-based learning positively influences learners' motivation, participation, knowledge acquisition, and academic achievement across various educational settings.

Among traditional Filipino games, Patintero encourages teamwork, communication, strategic thinking, and active participation, making it a promising instructional approach for collaborative learning. However, while previous studies have extensively examined digital games and commercially developed educational games, limited research has investigated the integration of traditional Filipino games into chemistry instruction, particularly in teaching balancing chemical equations. This gap highlights the need to develop and evaluate a culturally relevant learning approach that combines meaningful gameplay with chemistry instruction.

Therefore, this study developed and evaluated a Patintero-Based Learning Approach for teaching balancing chemical equations. The study examined the quality of the developed learning approach and evaluated its effectiveness in improving learners' performance. The findings provide evidence on the potential of integrating a traditional Filipino game into chemistry instruction to support meaningful learning, increase learner engagement, and improve understanding of balancing chemical equations.

Objectives of the Study

This study aimed to develop and evaluate a Patintero-Based Learning Approach for teaching balancing chemical equations. Specifically, it sought to:

1. examine the effect of the Patintero-Based Learning Approach on learners' performance in balancing chemical equations; and
2. assess learners' perceptions of the Patintero-Based Learning Approach in balancing chemical equations.

METHODOLOGY

This study employed a quasi-experimental research design to develop and evaluate a Patintero-Based Learning Approach for teaching balancing chemical equations. The study compared the performance of two independent groups, wherein the control group received conventional instruction, while the experimental group received the Patintero-Based Learning Approach. The study was conducted in a private school in Iligan City during the School Year 2025–2026.

The participants were 57 Grade 10 learners, with 28 learners assigned to the control group and 29 learners assigned to the experimental group. The participants were selected through random sampling. A researcher-developed Balancing Chemical Equations Test was used as the pretest and posttest to measure the learners' understanding of balancing chemical equations. The test underwent expert validation using the Content Validity Index (CVI) and was subjected to item analysis, including item difficulty and item discrimination, to examine the quality of the test items. The reliability of the pretest was determined using Cronbach's alpha, which yielded a coefficient of 0.73, indicating acceptable internal consistency. A perception questionnaire was

also administered to the experimental group, and its reliability was established using Cronbach's alpha, which yielded a coefficient of 0.74, indicating acceptable internal consistency.

The intervention was implemented over five days. On Day 1, the learners were oriented about the study and completed the pretest to determine their prior knowledge of balancing chemical equations. On Day 2, both groups received instruction on balancing chemical equations, including chemical formulas, coefficients, and the law of conservation of mass. On Day 3, the experimental group participated in the Patintero-Based Learning Approach using two themes: Equation and Coefficient. The chemical equations were placed inside the designated lines of the playing area, while coefficient cards were positioned outside the lines. Before entering a designated line, learners first solved the equation to determine the appropriate coefficients. They then entered the corresponding line and selected or placed the correct coefficient. The activity required learners to balance the number of atoms of each element on both sides of the equation, thereby reinforcing the law of conservation of mass. On Day 4, both groups completed the posttest, while on Day 5, the experimental group answered the perception questionnaire.

The data were analyzed using frequency, percentage, mean, and standard deviation for descriptive purposes. The Mann–Whitney U test was employed to determine whether a significant difference existed between the performance of the control and experimental groups, as the analysis involved two independent groups taught using different instructional methods. Specifically, the test was used to determine whether the instructional method was associated with differences in learners' performance in balancing chemical equations. The level of significance was set at $\alpha = 0.05$.

RESULTS AND DISCUSSION

The learners' performance was evaluated based on their scores in the assessment administered during the study. The learning activity focused on balancing chemical equations, particularly the application of the law of conservation of mass and the proper use of coefficients in balancing chemical equations. The learners' scores served as the basis for determining their performance and learning outcomes after the implementation of the Patintero-based learning approach.

The following tables present the results and corresponding discussion of the study on the development and evaluation of a Patintero-based learning approach for teaching balancing chemical equations. The results include the learners' performance and their perceptions of the developed learning approach.

Table 1

Learners' Performance Between the Control and Experimental Groups

GROUP	N	MEAN RANK	SUM OF RANKS
Control Group	28	14.91	417.50
Experimental Group	29	42.60	1235.50
TOTAL	57		
TEST STATISTIC	VALUE		
Mann–Whitney U	11.500		
Z	-6.311		
Asymp. Sig. (2-tailed)	< .001*		

*Significant at $\alpha = 0.05$.

Table 1 presents the results of the Mann–Whitney U test comparing the performance of the control and experimental groups after the implementation of the Patintero-Based Learning Approach. The analysis revealed a statistically significant difference between the two groups ($U = 11.500$, $Z = -6.311$, $p < .001$). Since the obtained p-value was lower than the 0.05 level of significance, the null hypothesis was rejected.

The experimental group obtained a substantially higher mean rank (42.60) than the control group (14.91), indicating that learners who were taught using the Patintero-Based Learning Approach demonstrated significantly higher learning gains in balancing chemical equations than those who received conventional instruction. These findings suggested that the Patintero-Based Learning Approach provided a more engaging and effective learning environment that facilitated learners' conceptual understanding of balancing chemical equations.

The improved performance of the experimental group could be attributed to the interactive and collaborative learning experiences provided by the Patintero-Based Learning Approach. Through structured gameplay, learners actively participated in balancing chemical equations, communicated with their peers, and applied scientific concepts while solving learning tasks. Such active engagement encouraged learners to construct knowledge through meaningful experiences rather than relying solely on teacher-directed instruction. Active participation has been recognized as an essential component of effective science learning because it promotes conceptual understanding, critical thinking, and long-term knowledge retention.

The findings of the present study are consistent with previous studies demonstrating the positive effects of game-based learning on learners' academic performance. A systematic review by Boyle et al., (2016) [1] concluded that educational games positively influenced learners' knowledge acquisition, motivation, engagement, and academic achievement across various educational settings. Similarly, Plass et al., (2015) [4] emphasized that game-based learning becomes most effective when game mechanics are intentionally aligned with instructional objectives, enabling learners to acquire concepts through active participation and meaningful interaction. More recently, studies by Verangel and Prudente (2022) [7] reported that game-based learning significantly improved learners' conceptual understanding on balancing chemical equations compared with conventional teaching approaches.

The present findings also support the principles of learner-centered and contextualized instruction promoted in science education. By incorporating a familiar traditional Filipino game into chemistry lessons, learners were encouraged to collaborate, communicate, and solve balancing tasks in an enjoyable learning environment. Such instructional experiences may have reduced learners' anxiety toward balancing chemical equations while increasing their confidence and motivation to participate in classroom activities. Consequently, learners developed a deeper understanding of balancing chemical equations, as reflected by the significantly higher performance of the experimental group.

Furthermore, the findings demonstrated that the Patintero-Based Learning Approach served as an effective instructional strategy for teaching balancing chemical equations. The significant difference observed between the experimental and control groups provided evidence that integrating a culturally familiar game into chemistry instruction enhanced learners' learning gains and promoted more meaningful classroom engagement.

Table 2

Learners' Perception of Patintero-Based Learning Approach

No. of Items	I find the...	Mean Ratings	Description
1	Patintero-based learning activity enhances my understanding of balancing chemical equation concepts.	3.52	Strongly Agree
2	Patintero-based learning activity more engaging in learning	3.34	Strongly Agree

	balancing chemical equations.		
3	Patintero-based learning activity provides a realistic representation of balancing chemical equations.	3.55	Strongly Agree
4	Patintero-based learning activity allows me to explore concepts related to balancing chemical equations.	3.38	Strongly Agree
5	Patintero-based learning activity helps me visualize better the process of balancing chemical equations.	3.48	Strongly Agree
6	Patintero-based learning activity is useful in understanding balancing chemical equations.	3.62	Strongly Agree
7	Patintero-based learning activity allows me to explore balancing chemical equations at my own pace.	3.34	Strongly Agree
8	Patintero-based learning activity has improved my ability to analyze balancing chemical equations effectively.	3.52	Strongly Agree
9	Patintero-based learning activity enhances my retention of knowledge about balancing chemical equations.	3.48	Strongly Agree
10	Patintero-based learning activity makes learning concepts in balancing chemical equations more relevant.	3.52	Strongly Agree
Grand Mean		3.48	Strongly Agree

Legend: 3.26–4.00 (Strongly Agree), 2.51–3.25 (Agree), 1.76–2.50 (Disagree), 1.00–1.75 (Strongly Disagree)

Table 2 shows that the learners had a strongly positive perception of the Patintero-based learning approach, as indicated by the grand mean of 3.48, interpreted as Strongly Agree. All ten indicators received mean ratings within the Strongly Agree range (3.26–4.00), suggesting that the activity was perceived as useful, engaging, relevant, and supportive of learning balancing chemical equations. The highest rating was obtained by Item 6 ($M = 3.62$), indicating that learners particularly perceived the activity as useful in understanding balancing chemical equations. This finding supports Wouters et al., (2013) [8], whose meta-analysis of 77 studies found that serious games produced positive effects on learning and retention compared with conventional instruction, particularly when games were supplemented with other instructional methods and collaborative activities.

The high ratings for Item 3 ($M = 3.55$), Items 1 and 8 ($M = 3.52$), and Item 10 ($M = 3.52$) further indicate that learners perceived the Patintero-based activity as providing a realistic representation, enhancing understanding, improving their ability to analyze equations, and making learning more relevant. These findings are consistent with Plass et al. (2015) [4], who explained that well-designed game-based learning can promote learners' cognitive, behavioral, affective, and sociocultural engagement when game elements are aligned with learning objectives. The findings also complement Verangel and Prudente (2022) [7], who reported that an instructional intervention using guided inquiry and particulate drawings significantly improved Grade 10 learners' conceptual understanding and confidence in balancing chemical equations.

Meanwhile, Items 2 and 7 obtained the lowest mean ratings of 3.34, but both were still interpreted as Strongly Agree. This indicates that learners still perceived the activity as engaging and supportive of exploring balancing chemical equations at their own pace, although these aspects were slightly less emphasized than the activity's usefulness for understanding the lesson. Moreover, the grand mean of 3.48 suggests that the Patintero-based learning approach was positively received by the learners and was perceived as a meaningful way of learning balancing chemical equations. However, since these results represent learners' perceptions,



they should be considered together with the objective performance results when determining the effectiveness of the intervention.

CONCLUSION

The study concluded that the Patintero-Based Learning Approach enhanced learners' learning of balancing chemical equations. The experimental group demonstrated better performance than the control group after the intervention, indicating that the approach provided meaningful opportunities for learners to apply and understand the process of balancing chemical equations.

The learners also positively perceived the Patintero-Based Learning Approach, particularly its usefulness, relevance, and contribution to their understanding of the lesson. The integration of a familiar traditional Filipino game created an interactive and collaborative learning experience that encouraged active participation in chemistry learning.

Furthermore, the findings support the use of the Patintero-Based Learning Approach as an alternative instructional strategy for teaching balancing chemical equations. It demonstrates how culturally familiar and interactive learning activities can be incorporated into chemistry instruction to make learning more meaningful and engaging for learners.

RECOMMENDATION

Based on the findings of the study, science teachers may consider integrating the Patintero-Based Learning Approach into chemistry instruction, particularly when teaching balancing chemical equations. The activity may be used as a supplementary strategy to encourage active participation, collaboration, problem-solving, and meaningful engagement in learning. Science teachers may also adapt the Patintero-based activity to other chemistry topics that involve problem-solving, application of concepts, or collaborative learning. Appropriate modifications may be made based on the learners' level, classroom conditions, available resources, and intended learning objectives.

Future researchers may conduct similar studies involving larger samples, different grade levels, and diverse learning environments to further examine the applicability of the approach. Longer-term studies are also recommended to determine whether the observed learning gains are sustained over time and to examine learners' retention, engagement, and continued application of balancing chemical equations. Further research may likewise explore the use of the Patintero-Based Learning Approach in other chemistry competencies and compare its effects across different instructional contexts.

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