Development and Preliminary Validation of the React Learning Packet for Teaching Chemical Reactions

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ABSTRACT

Chemical Reactions present considerable learning challenges for students, particularly in connecting observable changes in matter with particle-level explanations and symbolic representations such as chemical formulas and equations. This study focused on the development and preliminary validation of the REACT Learning Packet for Teaching Chemical Reactions.

A developmental research design was employed in three stages: development, preliminary validation through expert evaluation and refinement, and learner tryout. The packet was developed based on intended learning competencies and principles of the BSCS 5E Instructional Model and organized around five researcher-developed components: Relate, Explore, Act, Collaborate, and Transform. It incorporated contextualized learning activities, guided exercises, collaborative tasks, reflection, formative assessment, and the researcher-developed Find Your Chemistry Card Game. Six experts in Chemistry education and instructional material development evaluated the packet in terms of content accuracy, instructional design, usability and clarity, learning activities and assessment, and alignment with learning objectives.

The packet obtained an overall weighted mean of 4.77, interpreted as Highly Acceptable, while instructional design received the lowest rating (WM = 4.50, Acceptable). Expert feedback was incorporated into the refinement of the packet before learner tryout. The revised packet was implemented with 35 Senior High School STEM learners during two consecutive Chemistry class sessions. The mean score increased from 8.20 (SD = 2.08) to 13.51 (SD = 2.37). The Wilcoxon Signed-Rank Test showed a significant difference between pretest and posttest scores ($Z = -4.99$, $p < .001$, $r = .84$). Thus, the null hypothesis was rejected. The findings provide preliminary evidence supporting further development and evaluation of the REACT Learning Packet for teaching Chemical Reactions.

Keywords: Action research, Chemistry education, Chemical reactions, Game-based learning

INTRODUCTION

Understanding Chemical Reactions requires learners to connect observable changes in matter with explanations at the particle level and symbolic representations such as chemical formulas and equations. These representational demands make chemistry learning cognitively challenging because learners must coordinate different forms of representation rather than simply recall concepts or procedures (Popova & Jones, 2021; Rosyida et al., 2022). Chemical equations, in particular, require learners to interpret symbols and formulas while applying conceptual understanding of chemical change and conservation of matter. Such demands can make topics involving chemical equations and reactions difficult to learn when instruction focuses primarily on symbolic manipulation rather than conceptual connections (Avram et al., 2024).

The complexity of Chemical Reactions underscores the need for instructional materials that provide learners with structured opportunities to connect concepts with meaningful contexts and actively work with chemical representations. Context-based chemistry learning has been shown to support cognitive, affective, psychomotor, and social dimensions of learning, particularly when appropriate contexts are integrated with

suitable instructional strategies (Minata et al., 2022). In the Philippine context, the development of localized and contextualized Chemistry learning materials has likewise emphasized the importance of aligning content, activities, organization, and assessment with learners' needs and curriculum competencies (Dela Mines & Cajucom, 2022; Riparip, 2024). These findings suggest that well-designed learning materials can provide a more structured means of addressing content-specific learning demands.

Interactive and game-based activities provide another avenue for designing such learning experiences. Game-based learning can incorporate interaction, challenges, rules, feedback, and opportunities for learners to work with content in active ways. A systematic review of 57 studies found that educational games have been used across various chemistry topics and have contributed to students' conceptual understanding and motivation (Byusa et al., 2022). Similarly, a three-level meta-analysis involving 34 chemistry game-based learning studies reported positive effects on cognitive outcomes, retention, and motivation compared with non-game-based instruction, although substantial variation across studies indicates the importance of instructional and game-design features (Hu et al., 2022). Thus, the value of a game-based activity depends not simply on its inclusion, but on how it is integrated with content, learning objectives, and the broader instructional sequence.

The organization of these learning experiences is equally important. The BSCS 5E Instructional Model provides a constructivist basis for sequencing science instruction through engagement, exploration, explanation, elaboration, and evaluation. A recent systematic review and meta-analysis of 61 randomized controlled studies found positive effects of 5E-based instruction on science outcomes, while also noting variation across implementation contexts (Polanin et al., 2024). In Chemistry specifically, Sotáková and Ganajová (2023) found that 5E-based instruction influenced students' cognitive processes and attitudes toward Chemistry, using inquiry-based activities for a thematic unit on chemical reactions and equations. These findings support the use of the 5E model as a basis for organizing learning experiences that progressively engage learners in exploring, explaining, applying, and evaluating chemical concepts.

Despite the growing evidence supporting contextualized, game-based, and 5E-based instruction, there remains a need for systematically developed learning materials that integrate these principles into a coherent resource for teaching Chemical Reactions, particularly in the Philippine Senior High School context. Philippine studies have demonstrated the value of developing and evaluating Chemistry learning packets through expert and teacher assessment (Dela Mines & Cajucom, 2022; Riparip, 2024). However, existing instructional-material studies have generally focused on particular modules, localized content, or specific technologies and strategies. This indicates a need for learning materials in which the instructional sequence, contextualized activities, interactive resources, collaborative tasks, and assessment are deliberately organized around the learning demands of Chemical Reactions.

In response to this need, the present study developed the REACT Learning Packet for Teaching Chemical Reactions. The packet was guided by principles of the BSCS 5E Instructional Model and organized around five researcher-developed instructional components: Relate, Explore, Act, Collaborate, and Transform. It incorporates contextualized learning activities, guided exercises, collaborative tasks, reflection, formative assessment, and the researcher-developed Find Your Chemistry Card Game as a major activity within the Explore component. In this study, REACT refers specifically to the instructional structure developed for the learning packet, while the BSCS 5E Instructional Model serves as the instructional basis for its design.

Research Objectives

This study focused on the development and preliminary validation of the REACT Learning Packet for teaching Chemical Reactions. Specifically, it sought to:

- Develop the REACT Learning Packet for teaching Chemical Reactions;
- Determine the preliminary validity of the developed REACT Learning Packet in terms of:
    - content accuracy;
    - instructional design;
    - usability and clarity;

  - learning activities and assessment; and
  - alignment with learning objectives;
- Determine whether there is a significant difference between learners' pretest and posttest scores during the learner tryout of the REACT Learning Packet.

Research Hypothesis

H_0: There is no significant difference between the learners' pretest and posttest scores during the learner tryout of the REACT Learning Packet for Teaching Chemical Reactions.

METHODOLOGY

Research Design

This study employed a developmental research design focused on the development and preliminary validation of the REACT Learning Packet for teaching Chemical Reactions. The study was conducted in three stages: (1) development of the learning packet, (2) preliminary validation through expert evaluation and refinement, and (3) learner tryout.

The development stage involved designing the learning packet based on the intended learning competencies and principles of the BSCS 5E Instructional Model. The preliminary validation stage involved expert evaluation of the developed packet using an evaluation rubric, followed by refinement based on the evaluators' comments and recommendations. The final stage involved a learner tryout in which the developed packet was implemented with Senior High School STEM learners. Pretest and posttest scores obtained during the tryout were compared to provide preliminary evidence from the initial classroom use of the learning packet.

Research Setting and Participants

The study was conducted in a private secondary school in Iligan City during the first semester of Academic Year 2025–2026. The learner participants were thirty-five (35) Senior High School STEM learners enrolled in a Chemistry course covering Chemical Reactions. The learners were selected through convenience sampling, consistent with the classroom-based nature of the learner tryout.

For the preliminary validation, the REACT Learning Packet was evaluated by six (6) experts with backgrounds in Chemistry education and instructional material development. Their evaluation focused on the content, instructional design, usability, learning activities and assessment, and alignment of the packet with its intended learning objectives.

Development of the REACT Learning Packet

The REACT Learning Packet was developed as a researcher-developed instructional material for teaching Chemical Reactions. Its design was guided by the principles of the BSCS 5E Instructional Model and organized around five researcher-developed instructional components: Relate, Explore, Act, Collaborate, and Transform.

The packet incorporated contextualized learning activities, guided exercises, collaborative tasks, reflection activities, and formative assessment. A major learning resource embedded in the Explore component was the researcher-developed Find Your Chemistry Card Game, which provided learners with opportunities to identify, classify, construct, and analyze chemical reactions through interactive activities.

The five components of the REACT Learning Packet were organized as follows:

- Relate – activates learners' prior knowledge and connects Chemical Reactions to familiar or real-life situations;

- Explore – facilitates concept exploration through the Find Your Chemistry Card Game and other interactive learning activities;
- Act – provides guided exercises and problem-solving tasks through which learners apply concepts and skills;
- Collaborate – provides opportunities for learners to discuss ideas, explain reasoning, and work cooperatively; and
- Transform – encourages reflection and transfer of learning by connecting newly acquired knowledge to authentic situations and everyday experiences.

The packet was designed for implementation during two consecutive Chemistry class sessions within regular instructional time.

Preliminary Validation Through Expert Evaluation

The preliminary validation of the REACT Learning Packet was conducted through expert evaluation. The developed packet was submitted to six experts in Chemistry education and instructional material development.

An Evaluation Rubric for the REACT Learning Packet was used to assess the material in terms of content accuracy, instructional design, usability and clarity, learning activities and assessment, and alignment with learning objectives.

The experts reviewed the content and instructional components of the packet and provided comments and recommendations regarding its organization, clarity, presentation, activities, and alignment. The feedback obtained from the evaluation was reviewed by the researcher and used to refine the learning packet before the learner tryout.

Learner Tryout

Following the expert evaluation and subsequent refinement, the REACT Learning Packet was subjected to an initial learner tryout involving the thirty-five (35) Senior High School STEM learners. Before the implementation, the learners answered a researcher-developed Chemical Reactions Questionnaire as a pretest to determine their initial performance on the concepts addressed in the packet.

The REACT Learning Packet was then implemented during two consecutive Chemistry class sessions. Learners engaged in the activities and tasks included in the packet, including the Find Your Chemistry Card Game, guided exercises, collaborative activities, and reflection tasks. Immediately after the completion of the instructional sessions, the same Chemical Reactions Questionnaire was administered as a posttest.

The pretest and posttest scores were then compared to determine whether a statistically significant difference existed between learners' scores during the learner tryout. This stage was intended to provide preliminary evidence from the initial classroom use of the developed learning packet rather than definitive evidence of instructional effectiveness.

Research Instruments

Two instruments were used in the study: (1) the Evaluation Rubric for the REACT Learning Packet and (2) the Chemical Reactions Questionnaire.

Evaluation Rubric for the REACT Learning Packet

The Evaluation Rubric for the REACT Learning Packet was a researcher-developed instrument used to obtain expert judgments regarding the quality, appropriateness, and instructional design of the developed learning packet. The rubric consisted of 25 items distributed across five evaluation domains: content

accuracy, instructional design, usability and clarity, learning activities and assessment, and alignment with learning objectives. Each domain contained five items addressing key characteristics of the learning packet.

Each item was rated using a 5-point Likert-type scale, with response options ranging from 1 (Not Acceptable) to 5 (Highly Acceptable). The weighted mean for each domain and for the overall learning packet was computed and interpreted using the following predetermined intervals: 4.51–5.00 = Highly Acceptable; 3.41–4.50 = Acceptable; 2.61–3.40 = Moderately Acceptable; 1.81–2.60 = Less Acceptable; and 1.00–1.80 = Not Acceptable.

The rubric was developed based on the intended characteristics and quality requirements of the learning packet. The items were reviewed for relevance, clarity, and appropriateness prior to formal administration. Six experts in Chemistry education and instructional material development subsequently evaluated the REACT Learning Packet in terms of the five identified domains.

The ratings were summarized using weighted means for each evaluation domain and for the overall packet. The experts' qualitative comments and recommendations were also documented and considered during the refinement of the REACT Learning Packet before the learner tryout. Thus, the expert evaluation served as a preliminary validation and formative refinement process for the developed instructional material.

Chemical Reactions Questionnaire

The Chemical Reactions Questionnaire was a researcher-developed instrument designed to assess learners' understanding of the concepts addressed in the REACT Learning Packet. The questionnaire consisted of 20 multiple-choice items covering three major areas: identification and classification of chemical reaction types, balancing chemical equations, and application of chemical reaction concepts in problem-solving situations.

The items were developed based on the intended learning competencies and learning objectives addressed in the REACT Learning Packet. A test blueprint was prepared to ensure appropriate distribution of items across the targeted competencies and cognitive levels. The instrument covered the identification and classification of reaction types, balancing of chemical equations, and application of concepts in problem-solving situations.

Prior to administration, the questionnaire underwent expert validation to establish the content relevance, accuracy, clarity, and alignment of the items with the intended learning outcomes. Revisions were incorporated based on the recommendations of the validators to improve the quality and suitability of the items for Senior High School learners.

Each correctly answered item was assigned one point, while an incorrect or unanswered item received zero points, resulting in a total possible score of 20. The same questionnaire was administered as the pretest and posttest during the learner tryout to facilitate comparison of learners' scores before and after exposure to the REACT Learning Packet. The questionnaire was administered immediately before and after the two-session learner tryout.

Data Collection Procedure

Data collection followed three major stages corresponding to the developmental process of the study.

First, development. The REACT Learning Packet was developed based on the intended learning competencies and principles of the BSCS 5E Instructional Model. The packet was organized into the five REACT components and incorporated contextualized activities, guided exercises, collaborative tasks, reflection activities, formative assessment, and the Find Your Chemistry Card Game.

Second, preliminary validation and refinement. The developed packet was submitted to six expert evaluators for assessment using the evaluation rubric. Their ratings, comments, and recommendations were reviewed

and used to refine the packet before its classroom tryout.

Third, learner tryout. The revised learning packet was administered to thirty-five Senior High School STEM learners. The learners first completed the Chemical Reactions Questionnaire as a pretest. The REACT Learning Packet was then implemented during two consecutive Chemistry class sessions. After the implementation, the same questionnaire was administered as a posttest. The resulting pretest and posttest scores were analyzed to determine whether a significant difference existed between the two sets of scores.

Data Analysis

The expert evaluation data were analyzed using the weighted mean to summarize the evaluators' ratings for each criterion of the REACT Learning Packet. The overall weighted mean was also computed to describe the preliminary acceptability of the developed packet.

For the learner tryout, mean and standard deviation were used to summarize the pretest and posttest scores. The Kolmogorov–Smirnov test was used to examine the normality of the score distributions. Since the pretest and posttest scores did not meet the assumption of normality, the Wilcoxon Signed-Rank Test was used to determine whether a significant difference existed between the learners' pretest and posttest scores.

The effect size (r) was also computed to describe the magnitude of the observed difference. Statistical significance was evaluated at the 0.05 level of significance.

Ethical Considerations

Ethical approval was obtained prior to the conduct of the study. Participation was voluntary, and the learners were informed of the purpose of the study, their right to withdraw at any time, and the confidentiality of their responses. All collected data were anonymized and used solely for research purposes. No conflicts of interest were identified.

RESULTS AND DISCUSSION

Development of the REACT Learning Packet

The REACT Learning Packet was developed as a researcher-developed instructional resource for teaching Chemical Reactions. Its development was guided by the intended learning competencies and principles of the BSCS 5E Instructional Model. The packet was organized around five researcher-developed instructional components: Relate, Explore, Act, Collaborate, and Transform.

To clarify the relationship between the established BSCS 5E Instructional Model and the researcher-developed REACT structure, Table 1 presents the mapping of the 5E phases to the REACT components. The mapping identifies whether each REACT component is directly aligned with, adapted from, extended from, or added to the 5E instructional sequence.

Table 1Mapping of the BSCS 5E Instructional Model to the REACT Learning Packet

BSCS 5E Phase	Primary Instructional Function	REACT Component	Relationship to 5E	Application in the REACT Learning Packet
Engage	Activates prior knowledge, elicits interest, and establishes connections with learners' experiences	**Relate**	**Adapted**	Connects Chemical Reactions with learners' prior knowledge, familiar experiences, and real-life contexts.

Explore	Provides opportunities to investigate concepts and construct initial understanding	**Explore**	**Directly aligned**	Provides interactive opportunities to investigate Chemical Reactions, including the Find Your Chemistry Card Game.
Explain	Develops conceptual explanations and formalizes understanding	**Act**	**Adapted**	Provides guided activities through which learners articulate, represent, apply, and develop their understanding of Chemical Reactions.
Elaborate	Extends and applies learning to new situations and contexts	**Transform**	**Adapted and extended**	Provides opportunities for application, reflection, and transfer of learning to authentic situations.
Evaluate	Assesses learners' understanding and monitors learning	**Integrated across REACT**	**Integrated**	Formative assessment and reflection are incorporated throughout the learning sequence, particularly within application and transfer activities.
—	Peer interaction and cooperative construction of understanding	**Collaborate**	**Researcher-added**	Provides opportunities for discussion, peer interaction, justification of ideas, and cooperative learning across the REACT components.

The mapping shows that the REACT Learning Packet was informed by, but is not equivalent to, the BSCS 5E Instructional Model. The 5E model served as the established instructional basis, while REACT was developed as a distinct instructional structure for organizing learning experiences in Chemical Reactions. Relate adapts the function of Engage by connecting the topic with learners' prior knowledge and experiences, while Explore maintains a direct alignment with the exploratory function of the 5E model. Act adapts elements of Explain through guided activities that support learners in developing and applying their understanding. Transform extends the function of Elaborate by emphasizing application, reflection, and transfer of learning. Evaluation is integrated throughout the REACT sequence through formative assessment and reflection. In contrast, Collaborate is a researcher-added component that cuts across the other components by providing opportunities for peer interaction, discussion, and cooperative learning.

The specific components of the REACT Learning Packet are presented in Table 2.

Table 2 Components of the REACT Learning Packet

Component	Description
Relate	Activates learners' prior knowledge and connects Chemical Reactions to real-life situations.
Explore	Utilizes the researcher-developed Find Your Chemistry Card Game to facilitate concept discovery through interactive and collaborative activities.
Act	Provides guided activities and problem-solving tasks that enable learners to apply acquired

	concepts.
Collaborate	Encourages peer interaction, discussion, and cooperative learning to justify ideas and construct understanding.
Transform	Promotes reflection and transfer of learning by relating chemistry concepts to authentic situations.

The five components were deliberately organized to provide a coherent sequence of learning experiences. Relate establishes connections between learners' prior experiences and Chemical Reactions. Explore provides opportunities to investigate chemical concepts through interactive activities, with the Find Your Chemistry Card Game serving as a major learning activity. Through the game, learners identify, classify, construct, and analyze chemical reactions. Act then provides guided exercises and problem-solving tasks that allow learners to apply their developing understanding. Collaborate provides opportunities for learners to discuss ideas, justify their reasoning, and work cooperatively across the learning activities. Finally, Transform encourages learners to reflect on their learning and transfer chemical concepts to authentic situations.

The design of the packet integrates contextualized learning, game-based learning, collaborative learning, guided application, reflection, and formative assessment within a single instructional resource. These features were selected to provide learners with opportunities to connect Chemical Reactions with meaningful contexts, actively investigate and apply concepts, discuss their reasoning with peers, and reflect on their learning. Such an integrated design is consistent with literature emphasizing the value of contextualized chemistry learning, game-based learning, collaborative learning, and structured 5E-based instruction. Overall, the development process resulted in a researcher-developed instructional resource that uses the BSCS 5E Instructional Model as its instructional basis while organizing learning experiences through the five REACT components. The resulting packet includes contextualized activities, guided exercises, collaborative tasks, reflection, formative assessment, and the Find Your Chemistry Card Game, specifically designed to support the teaching and learning of Chemical Reactions.

Preliminary Validation Through Expert Evaluation

Validity and Acceptability of the REACT Learning Packet

Following development, the REACT Learning Packet underwent preliminary validation through expert evaluation. Six experts in Chemistry education and instructional material development evaluated the packet using five criteria: content accuracy, instructional design, usability and clarity, learning activities and assessment, and alignment with learning objectives. The evaluation results are presented in Table 3.

Table 3 Expert Evaluation of the REACT Learning Packet

Criterion	**Weighted Mean**	**Interpretation**
Content Accuracy	4.86	Highly Acceptable
Instructional Design	4.50	Acceptable
Usability and Clarity	4.73	Highly Acceptable
Learning Activities and Assessment	4.92	Highly Acceptable
Alignment with Learning Objectives	4.84	Highly Acceptable
Overall	**4.77**	**Highly Acceptable**

The REACT Learning Packet obtained an overall weighted mean of 4.77, interpreted as Highly Acceptable. Among the five criteria, Learning Activities and Assessment received the highest rating (WM = 4.92), followed by Content Accuracy (WM = 4.86) and Alignment with Learning Objectives (WM = 4.84). These ratings indicate that the expert evaluators generally considered the learning activities, assessment tasks, content, and alignment of the packet appropriate for its intended instructional purpose.

Usability and Clarity also received a Highly Acceptable rating (WM = 4.73), indicating that the packet was generally clear and usable. However, the rating suggests that there remained some aspects of organization or presentation that could be refined.

The lowest rating was obtained by Instructional Design (WM = 4.50), which was interpreted as Acceptable. Although this rating remained within an acceptable range, it indicates that instructional design was the area requiring the greatest attention during refinement. The evaluators' comments and recommendations were therefore considered in revising the organization, sequencing, presentation, and other applicable aspects of the packet before the learner tryout.

The expert evaluation served not merely as an assessment of the finished material but also as a formative stage in the development process. Expert review is commonly used in the development of instructional materials to examine content appropriateness, instructional organization, clarity, and alignment before classroom use. The present findings are consistent with studies on the development and evaluation of Chemistry learning materials, which emphasize expert and teacher review as an important step in improving instructional resources before implementation (Dela Mines & Cajucom, 2022; Riparip, 2024).

Overall, the evaluation results indicate that the REACT Learning Packet demonstrated acceptable preliminary quality across the evaluated criteria. At the same time, the lower rating for instructional design highlights the importance of incorporating expert feedback into iterative refinement, particularly when developing a new researcher-developed instructional resource.

Learner Tryout

Following expert evaluation and refinement, the REACT Learning Packet was subjected to an initial learner tryout involving 35 Senior High School STEM learners. The same Chemical Reactions Questionnaire was administered before and after the implementation of the packet. The pretest and posttest results are presented in Table 4.

Table 4 Descriptive Statistics and Test of Normality of Pretest and Posttest Scores

Test	Mean	SD	K–S Statistic	p-value	Interpretation
Pretest	8.20	2.08	0.146	.042	Not Normal
Posttest	13.51	2.37	0.172	.011	Not Normal

The mean pretest score was 8.20 (SD = 2.08), while the mean posttest score increased to 13.51 (SD = 2.37). The difference in descriptive scores indicates that learners obtained higher scores following their exposure to the REACT Learning Packet during the initial learner tryout.

Before conducting the inferential analysis, the distribution of the pretest and posttest scores was examined using the Kolmogorov–Smirnov test. The results showed that both the pretest ($p = .042$) and posttest ($p = .011$) distributions significantly deviated from normality. Thus, the assumption of normality for a parametric paired-samples procedure was not met. The Wilcoxon Signed-Rank Test, a nonparametric procedure for paired observations, was therefore used to examine whether the difference between the pretest and posttest scores was statistically significant.

Table 5 Wilcoxon Signed-Rank Test of Pretest and Posttest Scores

Comparison	Z	p-value	Effect Size (r)	Interpretation
Pretest vs. Posttest	−4.99	< .001	0.84	Large Effect

The Wilcoxon Signed-Rank Test revealed a statistically significant difference between the learners' pretest and posttest scores ($Z = -4.99$, $p < .001$). Therefore, the null hypothesis was rejected at the 0.05 level of significance. The computed effect size ($r = 0.84$) was large, indicating that the observed difference between the paired scores was substantial.

The increase in the posttest mean provides preliminary empirical evidence from the learner tryout that learners performed differently after working with the REACT Learning Packet. The result is consistent with the packet's design, which combines contextualized learning activities, interactive game-based learning, guided application, collaboration, and reflection within a structured instructional sequence. These features provide learners with multiple opportunities to encounter and apply Chemical Reactions rather than relying solely on direct explanation and symbolic manipulation.

The finding also corresponds with literature supporting the use of interactive and structured approaches in Chemistry learning. Game-based learning has been associated with positive learning outcomes when games are appropriately integrated with instructional objectives and content (Byusa et al., 2022; Hu et al., 2022). Likewise, contextualized learning provides opportunities for learners to connect abstract chemistry concepts with meaningful situations (Minata et al., 2022), while the 5E instructional model provides a structured sequence for engaging learners in exploration, explanation, application, and evaluation (Polanin et al., 2024; Sotáková & Ganajová, 2023).

However, the pretest–posttest findings should be interpreted as preliminary evidence from the learner tryout rather than definitive evidence of the effectiveness of the REACT Learning Packet. The study used a one-group design without a comparison group, and therefore the observed increase in scores cannot be attributed exclusively to the learning packet. Other factors, such as classroom instruction, prior learning, repeated exposure to the test content, or other aspects of the learning experience, may have contributed to the observed difference.

Nevertheless, the results provide an important initial indication that the developed packet is suitable for further investigation. The combination of favorable expert evaluation and the observed difference in learner scores supports proceeding to more extensive evaluation using larger samples, multiple school settings, and research designs that include appropriate comparison groups.

CONCLUSION

This study developed and preliminarily validated the REACT Learning Packet for Teaching Chemical Reactions as a researcher-developed instructional resource for Senior High School Chemistry. The packet was organized around five instructional components - Relate, Explore, Act, Collaborate, and Transform - and was guided by principles of the BSCS 5E Instructional Model. It incorporated contextualized learning activities, guided exercises, collaborative tasks, reflection, formative assessment, and the Find Your Chemistry Card Game.

The preliminary expert evaluation indicated that the REACT Learning Packet was Highly Acceptable overall (WM = 4.77) in terms of content accuracy, instructional design, usability and clarity, learning activities and assessment, and alignment with learning objectives. Although Instructional Design obtained the lowest rating (WM = 4.50, Acceptable), the evaluators' comments and recommendations were considered in refining the packet prior to the learner tryout.

During the learner tryout, the mean score increased from 8.20 (SD = 2.08) in the pretest to 13.51 (SD =

2.37) in the posttest. The Wilcoxon Signed-Rank Test showed a statistically significant difference between the pretest and posttest scores ($Z = -4.99$, $p < .001$), with a large effect size ($r = .84$). Thus, the null hypothesis was rejected at the 0.05 level of significance.

Overall, the findings provide preliminary evidence from the initial learner tryout supporting the continued development and further evaluation of the REACT Learning Packet. However, the observed pretest–posttest difference should not be interpreted as definitive evidence of the packet's effectiveness because the learner tryout employed a one-group design without a comparison group. Further evaluation involving larger samples, multiple school settings, and comparison-group or quasi-experimental designs is recommended to establish stronger evidence regarding the instructional value of the developed learning packet.

LIMITATIONS OF THE STUDY

This study has several limitations that should be considered when interpreting its findings. First, the learner tryout involved only 35 Senior High School STEM learners selected through convenience sampling from one private secondary school, which limits the generalizability of the findings to other learner populations and educational settings.

Second, the REACT Learning Packet was implemented over only two consecutive Chemistry class sessions, providing limited opportunity to examine sustained learning outcomes or longer-term retention.

Third, the learner tryout employed a one-group pretest–posttest design without a control or comparison group. Although a statistically significant difference was observed between the pretest and posttest scores, the design does not allow the change to be attributed solely to the REACT Learning Packet. Other factors, including regular classroom instruction, prior learning, testing effects, and other contextual influences, may have contributed to the observed difference.

Fourth, the posttest was administered immediately after the intervention, so the study did not examine retention of learning over an extended period.

Finally, the same Chemical Reactions Questionnaire was used for both the pretest and posttest, which may introduce testing or familiarity effects. These limitations constrain the extent to which the findings can be interpreted as evidence of causal effectiveness. The results should therefore be regarded as preliminary evidence from an initial learner tryout and should be followed by more rigorous validation involving larger and more diverse samples, comparison groups, and longer-term assessment.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations are proposed:

- Further refine the REACT Learning Packet, particularly its instructional design, based on the comments and recommendations provided by expert evaluators. Attention may be given to the organization, sequencing, clarity, and presentation of learning activities.

- Conduct further learner tryouts with larger and more diverse samples from different Senior High School contexts to examine the applicability and usability of the REACT Learning Packet across different groups of learners.

- Employ comparison-group or quasi-experimental designs in subsequent studies to provide stronger evidence regarding the contribution of the REACT Learning Packet to learners' performance.

- Further examine the individual components of the REACT Learning Packet, particularly the Find Your Chemistry Card Game, to determine how specific activities and instructional components contribute to learners' understanding of Chemical Reactions.

- Explore the adaptation of the REACT Learning Packet for other challenging Chemistry topics and investigate whether the same developmental approach can be used to create contextually appropriate and instructionally sound learning resources.

- Encourage Chemistry teachers to use the developed packet as a supplementary instructional resource, particularly for lessons requiring learners to connect chemical concepts, representations, and applications, while adapting the activities to their specific classroom context.

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