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Using Real-Time Simulations in Teaching Typhoons and Its Risks

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Abstract

Education is shifting towards modern approaches, particularly through integrating digital resources and STEM in the classroom. One key innovation in science education is simulation tools, which offer interactive and engaging ways to teach complex concepts. This study presents the development of a learning packet on typhoons and their associated risks, incorporating real-time simulation tools such as Project NOAH and Zoom Earth. These tools allow learners to visualize typhoon movements, interpret hazard data, and connect science concepts with real-life applications. Guided by the Successive Approximation Model (SAM), an iterative design process was followed to refine the learning materials through expert feedback continuously. A needs assessment among 25 in-service science teachers identified commonly used instructional materials—videos, PowerPoint presentations, and laboratory activities—with limitations in promoting deep learning. To address these gaps, two simulation-based learning activities were created and validated by 34 pre-service and five in-service teachers. Evaluation results showed strong agreement on the instructional design, clarity, and overall effectiveness of the learning packet, with ratings ranging from 3.71 to 3.96. Integrating real-time simulation tools supports STEM learning by making abstract meteorological processes more tangible and engaging. Moreover, this work aligns with SDG 4 (Quality Education) and SDG 13 (Climate Action) by fostering student disaster preparedness and scientific understanding, thereby contributing to global goals. This study demonstrates that simulation-driven instructional materials can enhance both conceptual understanding and climate resilience in science education.

Keywords: Typhoon, Risks, STEM Education, Real-time Simulations, Digital Resources, SDG 4, SDG 13

1. Introduction

Typhoons are among the most destructive natural disasters, with particularly severe impacts in countries like the Philippines. Due to its location in the Intertropical Convergence Zone (ITCZ), the Philippines experiences approximately 20 typhoons annually, many of which cause significant damage and loss of life (Santos, 2021). Given their frequency and vulnerabilities, teaching typhoon formation and its associated risks is essential for helping learners understand these phenomena and relate them to real-world contexts.

Understanding the process of typhoon formation is a crucial area in the Science 8 curriculum, yet it remains one of the least mastered competencies (Soberano & Matiras, 2024). Typhoons, being complex systems, present a challenge in grasping their characteristics (Chen & Li, 2024). Despite its significance, many instructional methods still rely on static and traditional materials that do not promote active engagement or conceptual understanding. This often leads to learners struggling to demonstrate competence and develop essential scientific thinking skills (Balansag, 2019). Textbooks, in particular, encourage surface-level learning rather than fostering deep understanding (Ambag, 2018). Traditional teaching strategies, moreover, often result in rote memorization rather than meaningful learning (Tabamo, 2023), which limits students' ability to apply scientific knowledge effectively (Abah, 2020).

There is an urgent need for engaging and up-to-date learning materials to address these instructional gaps. One promising solution is using structured learning packets—curriculum-aligned tools built around clear learning objectives that promote conceptual understanding and scientific skills development (Phoenix Union High School District, 1974). Integrating real-time simulation tools like Project NOAH and Zoom Earth allows learners to access live weather data, track typhoon movements, and analyze typhoon-induced hazards. This interactive approach supports the development of inquiry skills and deepens learners' understanding of typhoon behavior (Perkins, 2017; Juan et al., 2017).

A needs assessment conducted among 25 in-service teachers revealed that PowerPoint presentations, videos, simulations, laboratory activities, worksheets, and case studies are the most commonly used instructional materials. However, videos are often used passively, leading to surface-level learning (Wang, 2022), and static methods like laboratory activities and case studies lack the ability to immerse students in dynamic processes.

This study's instructional design is anchored in the Successive Approximation Model (SAM), a flexible and iterative model that supports the development of learner-centered instructional materials. SAM promotes rapid prototyping and cyclical feedback, making it ideal for designing context-sensitive educational resources (Allen, 2012). In science education, this iterative design process helps align learning objectives with real-time tools and active engagement strategies (Reiser & Dempsey, 2017).

This study developed a learning packet using the SAM model and integrated real-time simulation tools to respond to these challenges. This approach enhances STEM learning by making abstract meteorological concepts more accessible and interactive. Furthermore, it aligns with Sustainable Development Goals, specifically SDG 4 (Quality Education) and SDG 13 (Climate Action), by promoting equitable access to climate education and supporting disaster risk awareness.

Simulation tools, in particular, have shown great potential in effectively teaching dynamic scientific phenomena. Yuliati, Prasetyo, and Latifah (2018) found that such tools significantly improve students' understanding of atmospheric dynamics by promoting inquiry-based learning and deeper engagement. By allowing students to manipulate variables and visualize real-time processes, simulations have the power to transform abstract scientific concepts into concrete learning experiences and foster higher-order thinking skills essential for disaster awareness and climate resilience.

These findings underscore the pressing need for interactive, high-quality, and contextually relevant instructional materials. Such materials are crucial to improving typhoon education and enhancing students' conceptual understanding of meteorological systems.

2. Objectives of the Study

This study sought to attain the following research objectives:

1. Assess the existing learning materials, activities, and teaching strategies employed in teaching typhoons and its risks.
2. Develop a learning packet on typhoons and its risks.

3. Methodology

This study employed a developmental research design, strategically using the Successive Approximation Model (SAM) as its guiding framework for designing and evaluating a contextualized learning packet on typhoons and associated risks. The use of SAM was not arbitrary but a carefully considered decision, given its iterative and responsive structure, which supports the dynamic and evolving nature of instructional development in science education. The methodology was organized into three phases: Preparation, Iterative Design, and Iterative Development.

The Successive Approximation Model (SAM) offers a flexible and iterative approach to instructional design. Unlike traditional linear models, SAM emphasizes rapid prototyping, continuous feedback, and ongoing improvement. This emphasis on continuous improvement is particularly reassuring in dynamic learning environments such as science education. As Allen (2012) outlined, SAM allows for early and repeated testing of instructional materials, making it highly suitable for developing learner-centered and contextually responsive teaching tools.

3.1 Data Gathering Procedure

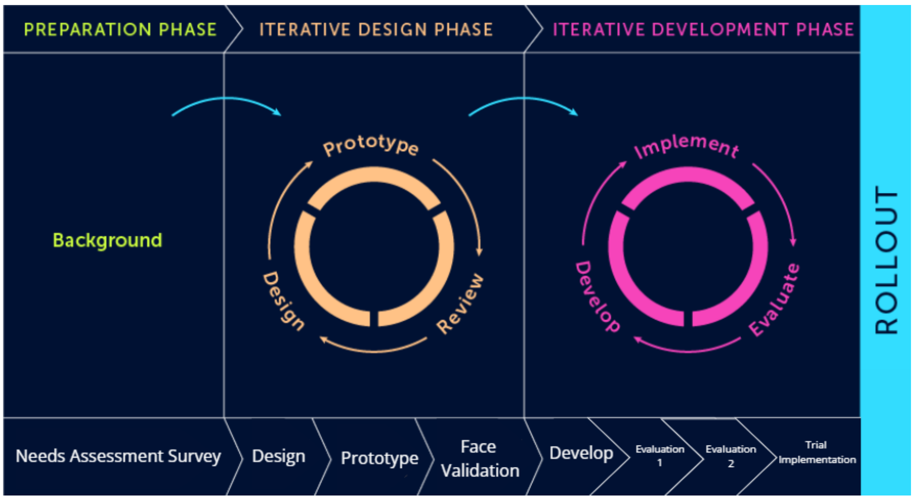

Figure 1. Successive Approximation Model

3.1.1 Preparation Phase: Needs Assessment Survey Questionnaire for Science Teachers

The development process commenced with a meticulous needs assessment involving 25 in-service science teachers from public and private secondary schools. Data were gathered using a structured, researcher-developed questionnaire that delved into existing instructional materials, teaching strategies, and classroom activities for teaching about typhoons and disaster risk. The collected responses were systematically tabulated and analyzed through content analysis, a rigorous process identifying common instructional gaps, recurring challenges, and areas requiring pedagogical support. These insights formed a robust empirical foundation for the learning packet, ensuring that its content directly addressed the instructional needs identified in actual classroom settings.

3.1.2 Iterative Design Phase

Based on the insights gathered from the needs assessment, the iterative design phase involved assembling relevant instructional materials drawn from curriculum-aligned junior high school science textbooks, credible academic websites, and interactive simulation platforms such as Project NOAH and Zoom Earth. These resources were carefully selected to enhance learners' conceptual understanding of typhoon formation, movement, and disaster-related impacts—previously identified as needing instructional reinforcement.

- The initial version of the learning packet was designed to include the following components:
- Two structured learning activities focused on guided concept-building through a worksheet, while the other engaged students in a simulation-based task that allowed them to observe and interpret real-time typhoon data.
- A researcher-developed achievement test: The test, which consists of 30 multiple-choice questions, aimed to assess students' knowledge and application of key scientific concepts related to typhoons and disaster preparedness.

To ensure the materials' clarity, accuracy, and relevance, the prototype was subjected to face validation by a panel of research advisers with expertise in science education. Their review focused on content alignment, instructional appropriateness, item construction, and overall coherence of the packet. A Table of Specifications (TOS) was also developed to guide the construction of the achievement test, ensuring that test items were appropriately distributed across the targeted learning competencies and cognitive levels. Based on the advisers' feedback, refinements were made to improve question phrasing, sequencing of tasks, and the overall presentation of the learning materials.

This phase ensured that the learning packet's instructional design was theoretically grounded and responsive to the classroom realities it aimed to address.

3.1.3 Iterative Development Phase

This phase involved the development of two learning activities, collectively called the learning packet, which integrated real-time simulation tools such as Project NOAH and Zoom Earth. The second prototype of the packet was initially evaluated by thirty-four (34) pre-service teachers. Their suggestions were carefully reviewed, and relevant feedback was incorporated into the subsequent revision of the materials. Following this, the third prototype was evaluated by five (5) in-service science teachers, whose comments and recommendations were also considered to refine the instructional content and delivery further. After the revisions were completed, the learning packet underwent trial implementation. The teacher approved its use upon review, indicating readiness for formal classroom application.

3.1.4 Actual Implementation

The actual implementation was conducted in one of the secondary schools in Lanao del Norte, involving seventy (70) Grade 8 learners. Following the completion of the instructional activities, a posttest was administered to assess the learners' understanding of the concepts presented in the learning packet. In addition, the researcher gathered the learners' perceptions regarding the effectiveness, clarity, and engagement value of the materials through a structured feedback process.

3.2 Alignment with Research Objectives

This methodological framework directly addressed the study's two research objectives.

For Objective 1, which aimed to assess the existing learning materials, activities, and teaching strategies used in teaching typhoons and their associated risks, a needs assessment survey was conducted among 25 in-service science teachers. Their responses were analyzed using content analysis to identify common instructional practices and limitations. This phase provided empirical evidence of gaps in current teaching methods, particularly the reliance on passive media and static materials.

For Objective 2, which focused on developing a contextualized learning packet, the SAM framework was applied through iterative design and development. Resources gathered from the needs assessment informed the creation of two structured learning activities incorporating real-time simulation tools. These materials underwent face validation, multiple rounds of evaluation, and a field implementation involving 70 Grade 8 learners. Feedback from both pre-service and in-service teachers contributed to continuous refinement, ensuring instructional quality and relevance.

4. Results and Discussion

The study began by identifying the current instructional practices science teachers use to teach about typhoons and their associated risks. Table 1 summarizes the learning materials, activities, and strategies employed, categorized into two primary domains: digital resources and collaborative learning strategies.

Table 1 presents teachers' learning resources to teach typhoon concepts and associated risks to Grade 8 learners, categorized into two main approaches: digital resources and collaborative learning. Under digital resources, three types were identified: PowerPoint presentations, videos, and simulations.

Videos were the most frequently used digital resource, mentioned eight times, followed by simulations and PowerPoint presentations. Most teacher-respondents who used videos practiced a passive approach, allowing learners to watch and react, often leading to surface-level learning. As emphasized in the study of Brame (2016), videos alone are insufficient without purposeful and proper use.

Simulations used by seven teacher-respondents were valued for helping learners visualize typhoon formation and movement. Teachers noted that simulations effectively illustrate how environmental factors affect typhoon strength. Research supports simulations as powerful tools for teaching complex scientific concepts, offering dynamic visuals and real-time data that promote inquiry-based learning and enhance problem-solving skills (Perkins, 2017; Moore et al., 2013; Tweed, 2009).

Regarding collaborative learning, laboratory activities were mentioned six times but were limited in scope. These oftentimes involved simple vortex demonstrations, which, while hands-on, could not fully capture the dynamic nature of typhoons (Jingco, 2019). Two teachers used case studies with real-life examples, but this method risks becoming outdated as theories evolve (Lederman et al., 2014), and typhoon strengths vary.

Overall, the findings highlight the limitations of static methods like laboratory experiments and case studies. Simulations emerged as the most effective approach, providing interactive, real-time learning experiences that enhance learners' understanding of typhoons and their risks.

Table 1: Learning Materials, Activities and Teaching Strategies Used in Teaching the Topic

Category	Learning Materials Used	Mention	Utterances
Digital Resources	PowerPoint Presentation	1	*"I utilized PPT to teach typhoon so I can show online videos and pictures of real-life examples of causes and effects of typhoon." (R3)* *"Interactive discussions using video showing "(R1)*
	Videos	8	*"Simply allowing them to watch videos and react to it. (R16, R18, R22–R25)* *"I used video from YouTube to teach the topic on typhoon". (R2).*
	Simulation	7	*"Interactive Simulations, or online tools or apps that simulate the movements of typhoons". (R8, R11, R14, R12, R20, R21)* *"I use simulations that allow learners to visualize how the environment where the typhoon is formed or developed affects its strength". (R1)*
Collaborative Learning	Laboratory & Experiments	6	*"Laboratory activities and letting them answer questions afterward". (R5, R8, R9)* *"Group activities such as experiments where students collaborate on typhoons". (R4, R10, R19)*
	Worksheet-Based Activities	1	*"I provided a worksheet entitled 'Weather Map Interpretation' where students learn to interpret weather maps and track typhoons' movements". (R6)*
	Case Studies & Real-Life Examples	2	*"I tasked my students an activity where students show their talent through role-playing of emergency scenarios on typhoon impacts and safety". (R13)* *I" basically incorporate real-life examples and let them watch or read case studies to connect learning to real-world events". (R17)*

Evaluation of the Developed Learning Packet

To address the second research objective, two structured learning activities, Tracing Typhoon Movements and Know Your Hazards, were developed and subjected to expert validation by both pre-service and in-service teachers. Their evaluations, summarized in Tables 2 and 3, provided insights into the instructional quality, clarity, and alignment of the learning materials.

Table 2: Evaluators Rating on Designed Learning Activity 1: Tracing Typhoon Movement

Factor	Pre-Service	In-Service	Description
Instructional Design and Organization	3.66	3.89	Strongly Agree
Language/Content/Format	3.76	3.80	Strongly Agree
Overall Mean	**3.71**	**3.85**	**Strongly Agree**

Note: 4.00-3.25- Strongly Agree 3.24-2.50- Agree 2.49-1.75- Disagree 1.74-1.00- Strongly Disagree

Table 2 shows the evaluation ratings from pre-service and in-service teachers on the designed learning activity, Tracing Typhoon Movements. In terms of Instructional Design and Organization and Language/Content/Format. The results indicate that both groups of evaluators "strongly agree" on the effectiveness of the learning activity, with pre-service teachers giving an overall mean rating of 3.71 and in-service teachers rating it slightly higher at 3.85. Among the factors assessed, Instructional Design and Organization received a mean score of 3.66 from pre-service teachers and 3.89 from in-service teachers, highlighting the activity's structured approach to fostering engagement and higher-order thinking. Similarly, Language/Content/Format was rated 3.76 and 3.80, respectively, demonstrating clarity and accessibility. The activity utilized Zoom Earth to allow learners to visualize typhoon movements in real-time and real-life situations in safe, reasonable, and sometimes even impossible situations (Becker& Parker, 2009). Furthermore, research by Biggs and Tang (2011) underscores the importance of well-structured instructional materials in achieving constructive alignment, ensuring that learning objectives, activities, and assessments work cohesively to enhance learners' understanding.

Table 3: *Evaluators Rating on Designed Learning Activity 2: Know Your Hazards*

Factor	Pre-Service	In-Service	Description
Instructional Design and Organization	3.71	3.97	Strongly Agree
Language/Content/Format	3.85	3.95	Strongly Agree
Overall Mean	**3.78**	**3.96**	**Strongly Agree**

Note:. 4.00-3.25- Strongly Agree 3.24-2.50- Agree 2.49-1.75- Disagree 1.74-1.00- Strongly Disagree

Table 3 presents the evaluation ratings from pre-service and in-service teachers on the learning activity Know Your Hazards. The results indicate an overall "Strongly Agree" rating across all two factors. For Instructional Design and Organization, pre-service teachers gave a mean rating of 3.71, while in-service teachers rated it 3.97. These scores suggest the activity is well-structured, engaging, and aligned with the Most Essential Learning Competencies (MELCs). Know Your Hazards incorporated Project NOAH, allowing learners to analyze actual hazard data, which aligns with research emphasizing that interactive and well-structured lessons enhance comprehension and problem-solving (Bruner, 1966; Vygotsky, 1978).

Regarding Language/Content/Format, the activity received ratings of 3.85 (pre-service) and 3.95 (in-service), reflecting intense clarity and accessibility. However, evaluators suggested refining sentence structures for better learner comprehension. This is consistent with Cognitive Load Theory (Sweller, 2010), which highlights that minimizing extraneous cognitive load—such as overly complex language—improves learning efficiency. Similarly, Mayer (2005) supports that clear and concise instructional materials enhance learner retention and understanding.

5. Conclusion

This study highlights the effectiveness of real-time simulations in learning activities designed to enhance Grade 8 students' understanding of typhoon formation and associated risks. By integrating Zoom Earth and Project NOAH, these activities provided interactive, hands-on experiences, allowing learners to explore typhoon movements dynamically and assess its risks to certain areas. The SAM (Successive Approximation Model) process guided the iterative development of the learning packet, ensuring adaptability and instructional coherence. Findings revealed that well-structured learning activities significantly improve learners' conceptual understanding. Strong ratings from both pre-service and in-service teachers validate the effectiveness of these simulations in promoting deeper engagement and understanding. Integrating real-time simulations into the science curriculum enhances academic performance and plays a vital role in disaster preparedness, particularly in typhoon-prone regions like the Philippines. While the study confirms the value of interactive learning, enhancing assessment strategies could further strengthen knowledge retention and application. This study further advocates for the broader adoption of Project NOAH and Zoom Earth in science education to improve conceptual understanding, learners' engagement, and preparedness for natural disasters.

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APPENDIX

Needs Assessment Questionnaire for Teachers

1. In your experience, what are the learning materials you employ in teaching typhoon and its risks?
2. What are the learning activities you employ in teaching typhoon and its risk?
3. How do you deliver the topic or what teaching strategies do you employ in teaching typhoons and its risks?