

Implementing Research-Based Science Activities in a Rural ESL Classroom: Usability, Pupil Learning and Instructional Value

Su Shiang Wong ^{1*} and Pik Kuong Ling ²

^{1,2} Faculty of Education, Open University, Selangor, Malaysia

ABSTRACT

This study examined the implementation of a researcher-designed Science Research-Based Activity (SRA) sequence in a rural Year 5 ESL classroom in Sarawak with limited infrastructure and teaching materials. The sequence organised Survey, Case Study, and Experimental Science Activities as a connected progression. Using Action Research supported by the Successive Approximation Model, 23 pupils completed nine cycles from 24 November to 11 December 2025, with 595 minutes (9 hours 55 minutes) of planned instructional time. Data included written pupil responses, classroom observations, semi-structured interviews with the teacher-researcher, reflection records, field notes, pupil artefacts, activity outputs, and cycle-level classroom-performance ratings. Engagement and activity-specific Learning Outcomes were summarised descriptively, while qualitative data were analysed thematically. Engagement increased broadly from $M = 5.17$ ($SD = 1.37$) out of 8 in Cycle 1 to $M = 7.43$ ($SD = 0.79$) in Cycle 9. Learning Outcomes varied with task demands, ranging from $M = 5.35$ ($SD = 1.58$) to $M = 7.57$ ($SD = 1.70$) out of 12, and generally improved within phases. High engagement did not always coincide with strong scientific explanation, particularly during hands-on work. The SRA sequence was workable when clear stages, adaptive scaffolding, accessible materials, language support, and teacher adjustment were used. Findings are specific to this classroom and do not establish causal effectiveness.

ARTICLE HISTORY

Received 13 August 2026
Revised 12 October 2026
Accepted 16 October 2026
Online First 16 October 2026

KEYWORDS

Action Research; ESL classroom; primary Science; education; research-based Science; activities; rural school

1. Introduction

Primary Science education requires pupils to engage actively with scientific questions, evidence, and practical investigation (Bennett et al., 2023; Ogegbo et al., 2025). However, implementing research-based Science activities can be more difficult in rural ESL classrooms where teachers and pupils work with limited resources, varying English proficiency, and practical classroom constraints (Iturbe-Sarunic et al., 2026; Mat Noor, 2022; Rupiwin & Shah, 2021). This article contributes an implementation-focused account of how a progressive research-based Science sequence operated and was refined across nine classroom Action Research cycles, rather than evaluating outcomes alone.

1.1. Problem Background

Primary Science learning involves more than acquiring scientific facts. Pupils also need opportunities to ask questions, make observations, gather information, examine evidence, solve problems, and explain what they have learned (Oguz-Unver & Yurumezoglu, 2014; Ogegbo et al., 2025). Inquiry and practical activities can provide these opportunities when they are connected to clear scientific knowledge and skills. Bennett et al. (2023) noted that primary Science activities are most useful when they form a coherent learning sequence rather than a collection of separate tasks.

Implementing such activities can be more difficult in rural and resource-limited schools. Limited laboratory facilities, teaching materials, equipment, and reliable digital access may restrict the activities that teachers can conduct regularly (Aidoo, 2024). Teachers may also need additional preparation time to obtain materials and organise practical work (Iturbe-Sarunic et al., 2026; Mat Noor, 2022). These conditions do not prevent active Science learning, but they affect how activities need to be designed and carried out.

Language is another important consideration when pupils learn Science through English as a second language (ESL). Language access and conceptual understanding were treated as related but distinct issues in this study. A pupil could understand an observation yet have difficulty expressing it in English, while another could use the relevant vocabulary but still struggle to explain the scientific relationship. The SRA design therefore combined language scaffolds, including simplified wording, visuals, sentence support, and bilingual clarification, with conceptual support through guiding questions, structured recording, discussion, and reflection. Van Driel et al. (2018) showed that scientific-language development requires planned teacher support, while Bennett et al. (2023) reported the value of linking Science learning with suitable language and literacy support. In rural Sarawak, Yunus and Jong (2016) similarly found that unfamiliar English vocabulary could affect pupils' engagement and understanding.

1.2. Problem Statement

Research-based Science activities do not automatically become effective classroom practice simply because pupils are given opportunities to investigate (Bennett et al., 2023; van Eijck et al., 2025). Primary pupils may still require clear instructions, guiding questions, visual support, structured recording formats, suitable materials, and teacher assistance (Kamarudin & Mat Noor, 2024; van Eijck et al., 2025). The amount of support may also change according to the activity and pupils' readiness. Kamarudin and Mat Noor (2024) found that primary Science teachers need systematic guidance in planning and implementing classroom activities. Their review also noted that Action Research studies often report learning outcomes without giving enough attention to how activities were implemented and improved in the classroom.

This issue is particularly important in rural ESL classrooms (Iturbe-Sarunic et al., 2026; Rupiwin & Shah, 2021). Activities that appear suitable during planning may work differently when pupils have difficulty understanding instructions, using materials, working in groups, recording findings, or explaining their reasoning (Greenwood et al., 2022; van Driel et al., 2018). Lesson time, available resources, and differences in pupil participation may also affect implementation (Aidoo, 2024; Greenwood et al., 2022).

The Science Research-Based Activity (SRA) approach examined in this study is a researcher-designed, progressive instructional sequence for primary Science. It is not proposed as a new learning theory or as a separate pedagogical model. Instead, it organises Survey, Case Study, and Experimental Science Activities into one connected sequence. The Survey phase draws mainly on guided inquiry; the Case Study phase uses problem-based features; and the Experimental Science Activity phase emphasises practical investigation with selected project-based features. The sequence was designed for a rural Year 5 ESL Science classroom in Sarawak with limited infrastructure and teaching materials.

The SRA activities were implemented with 23 Year 5 pupils across nine Action Research cycles. Unlike the earlier development stage of the SRA guide, the present article focuses on classroom implementation. It examines whether

the activities provided a workable structure under the conditions of the participating rural ESL classroom, what evidence of pupil learning emerged, and which classroom conditions affected their instructional value.

1.3. Research Objectives

The objectives of this study were:

- To examine the classroom usability of the SRA activities in a rural primary ESL Science classroom.
- To examine evidence of pupil learning and instructional value during the implementation of the SRA activities.

1.4. Research Questions

This study addressed the following research questions:

- How usable were the SRA activities in a rural primary ESL Science classroom?
- What evidence of pupil learning and instructional value emerged during their implementation?

2. Literature Review

2.1. Research-Based Learning in Primary Science

Research-based Science learning involves pupils in activities such as questioning, observing, gathering information, investigating problems, interpreting evidence, and communicating findings (Oguz-Unver & Yurumezoglu, 2014; Ogegbo et al., 2025). These activities support active participation in scientific processes rather than limiting pupils to receiving information from the teacher (Bennett et al., 2023; Oguz-Unver & Yurumezoglu, 2014). Bennett et al. (2023) found that primary Science approaches involving inquiry, practical investigation, collaboration, contextualised learning, and the integration of Science with language and literacy can support pupils' learning. However, the activities need to form a coherent sequence and remain connected to clear scientific knowledge and skills (Bennett et al., 2023; van Eijck et al., 2025).

Inquiry-based, problem-based, and project-based approaches are commonly used to organise active Science learning (Uluçinar, 2023; Zhou et al., 2025). Inquiry-based learning supports questioning, observation, information gathering, and evidence interpretation (Alake-Tuenter et al., 2012; Ogegbo et al., 2025). Problem-based learning involves pupils in examining contextual problems and considering possible explanations or responses (Uluçinar, 2023). Project-based learning places greater emphasis on planning, practical work, testing, collaboration, and presentation (Zhou et al., 2025). Although these approaches have different emphases, they can overlap in classroom practice and may be used progressively according to the demands of an activity (Zhou et al., 2025).

The literature supports the instructional features used in the three SRA phases, but it does not prescribe the exact Survey → Case Study → Experimental Science Activity order. That progression was a design decision in the present study, intended to move pupils from structured information gathering to contextual problem analysis and then to practical investigation while retaining teacher scaffolding according to pupil and task needs.

Primary pupils usually require guidance when they participate in these forms of learning (Alake-Tuenter et al., 2012; van Eijck et al., 2025). Open-ended tasks alone may not provide sufficient support for pupils who have limited previous experience with inquiry or research activities (Kamarudin & Mat Noor, 2024; van Eijck et al., 2025). Kamarudin and Mat Noor (2024) reported that primary Science teachers need incremental guidance in planning and implementing Science lessons and activities. Appropriate support may include clear activity stages, guiding questions, structured recording formats, visual materials, teacher prompts, and opportunities for discussion and reflection (Kamarudin & Mat Noor, 2024; van Eijck et al., 2025). Such support can help pupils participate more independently without removing the teacher's role in guiding scientific reasoning (Alake-Tuenter et al., 2012; van Eijck et al., 2025).

2.2. Rural and ESL Conditions Affecting Implementation

Research-based Science activities are influenced by the conditions in which they are implemented. Rural and under-resourced schools may have limited access to laboratories, specialised equipment, teaching materials, stable internet connections, and professional support (Aidoo, 2024; Iturbe-Sarunic et al., 2026; Mat Noor, 2022). These constraints can affect the regular implementation of inquiry and practical Science activities and require teachers to adapt activities according to available materials, lesson time, pupil readiness, and classroom organisation (Aidoo, 2024; Iturbe-Sarunic et al., 2026). Rural settings can also provide local materials and contexts that support meaningful Science learning (Aldea & Dayawon, 2025; Iturbe-Sarunic et al., 2026).

The use of accessible and low-cost materials can make practical Science activities more feasible in resource-limited settings (Aldea & Dayawon, 2025; Mat Noor, 2022). However, simple materials do not remove the need for preparation, testing, organisation, safety considerations, and suitable lesson planning (Mat Noor, 2022). Teachers must still decide whether materials are appropriate for the scientific purpose of an activity and whether pupils can use them effectively within the available lesson time. Classroom usability therefore depends not only on the written activity but also on the teacher's ability to adjust procedures and resources to local conditions (Iturbe-Sarunic et al., 2026; Kamarudin & Mat Noor, 2024).

ESL conditions add another layer of difficulty. Science learning requires pupils to understand instructions, use scientific vocabulary, describe observations, discuss evidence, and explain conclusions (Bennett et al., 2023; van Driel et al., 2018). Rural Malaysian pupils may experience additional difficulty when unfamiliar English vocabulary or limited second-language proficiency affects comprehension and participation (Rupiwin & Shah, 2021; Yunus & Jong, 2016). Pupils may therefore require simplified instructions, visuals, sentence support, bilingual clarification, teacher questioning, and other forms of language scaffolding to participate effectively in Science activities (Rupiwin & Shah, 2021; van Driel et al., 2018).

Language support is important when pupils move beyond practical participation to scientific explanation. Completing an experiment or group task does not necessarily demonstrate understanding of the scientific idea involved (Bennett et al., 2023; van Eijck et al., 2025). Pupils may complete procedures successfully but still have difficulty explaining why a result occurred or connecting observations with scientific concepts (Cabello et al., 2021; van Eijck et al., 2025). Discussion, structured recording, questioning, and reflection can help pupils connect practical experience with evidence and scientific explanation (McCrory, 2018; van Driel et al., 2018; van Eijck et al., 2025).

2.3. Classroom Usability and Research Gap

Much of the literature on inquiry and active Science learning has focused on outcomes such as engagement, achievement, motivation, conceptual understanding, and higher-order thinking (Ölçer, 2025; Ogegbo et al., 2025; Uluçınar, 2023). These outcomes are important, but they do not fully explain how an instructional approach operates during actual classroom implementation. Teachers also need to know whether activities are manageable, what kinds of support pupils require, which difficulties emerge, and what adjustments are needed when classroom conditions change (Alake-Tuenter et al., 2012; Greenwood et al., 2022; van Eijck et al., 2025).

Kamarudin and Mat Noor (2024) noted that Action Research studies in primary Science often emphasised outcomes while providing less detail about how classroom activities were implemented and improved. Their review also showed that inquiry implementation depended on prior knowledge, differentiated learning, scaffolding, learning by doing, and opportunities for pupils to express and report ideas. Similar implementation concerns have been reported in primary Science, including the need for teacher guidance, suitable lesson time, support for scientific vocabulary, and practical classroom adjustment (Greenwood et al., 2022; van Eijck et al., 2025).

Existing studies have often examined particular instructional models or specific forms of inquiry, problem-based learning, or project-based learning (Uluçınar, 2023; Zhou et al., 2025). The specific research gap addressed here is the limited classroom evidence on how different forms of research activity can be organised as one progressively demanding sequence and iteratively refined during use in a rural ESL primary Science setting with limited resources.

The gap is therefore not the absence of established IBL, PBL, or PjBL approaches, but the lack of detailed implementation evidence concerning their staged use, adaptation, and classroom manageability in this context. The limited empirical attention to rural Science contexts further supports the need to examine implementation under local classroom conditions (Iturbe-Sarunic et al., 2026).

Classroom usability in this study refers to the manageability of the instructions, materials, language support, task organisation, teacher facilitation, and lesson procedures under actual classroom conditions. Observable indicators included whether pupils could begin and complete the intended task, record required evidence, participate with manageable levels of clarification and support, and use the available materials within lesson constraints. Instructional value refers to the extent to which the activities supported useful learning experiences and evidence of learning, including participation in research-related processes, scientific discussion, practical investigation, evidence recording, interpretation, and explanation. Engagement, confidence, and scientific understanding were not treated as interchangeable outcomes.

The present study addresses this gap by examining the implementation of the Science Research-Based Activity (SRA) approach across nine Action Research cycles in one rural Year 5 ESL classroom in Sarawak. Rather than focusing only on the development of the guide, the article examines how the activities operated during classroom use, what evidence of pupil learning emerged, and which conditions affected their usability and instructional value.

3. Method

This study used Action Research (AR) as the primary research design, with the Successive Approximation Model (SAM) used to support iterative revision of the instructional materials. AR provided the recurring process of planning, action, observation, and reflection (Kemmis et al., 2014). SAM did not function as a second research methodology or as an effectiveness test; it supported practical revisions to instructions, scaffolds, recording formats, materials, grouping, timing, and activity procedures when classroom evidence indicated that changes were required (Allen & Sites, 2012). Figure 3.1 shows these distinct but connected functions.

3.1. Research Design and Participants

The study was conducted in a rural government primary school in Sarawak, Malaysia. The site was classified as rural within its local education context and had limited specialised Science equipment and teaching materials, no fully equipped Science laboratory for routine use, and inconsistent digital access. One intact Year 5 class comprising 23 pupils participated. Individual age was not used as an analytic variable; all participants belonged to the same normal Year 5 cohort. The class included mixed levels of English proficiency, learning readiness, and prior experience with inquiry. English proficiency and previous Science achievement were not independently standardised or used for selection. The class was selected purposively because it represented the rural, resource-limited ESL setting for which the SRA activities were designed.

The researcher was the regular Science teacher of the participating class and served as teacher-researcher throughout the study. This role allowed classroom difficulties and pupil responses to be observed directly across the nine cycles. It also required systematic documentation and reflection because the researcher was involved in both implementation and evaluation.

3.2. SRA Implementation

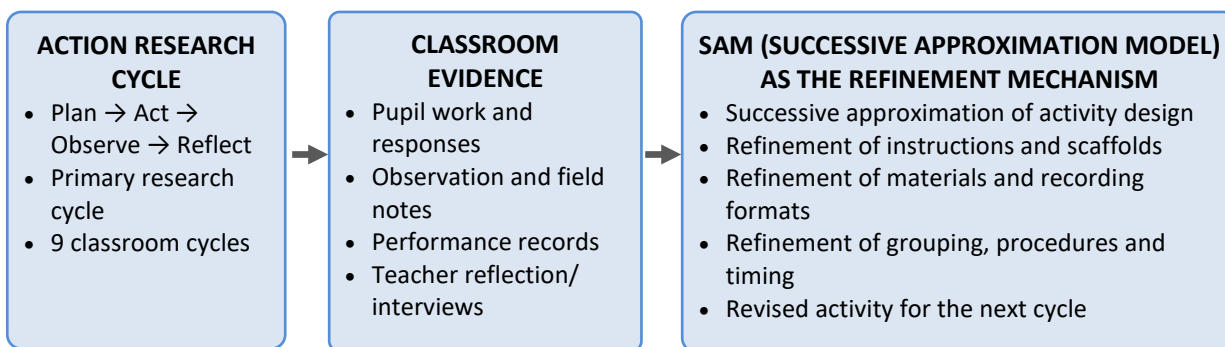
The nine AR cycles were organised into three phases. Survey activities in Cycles 1–3 introduced pupils to questioning, observation, information gathering, recording, and communication. Case Study activities in Cycles 4–6 required pupils to examine contextual Science problems, identify relevant information, discuss possible explanations, and develop responses. Experimental Science Activities in Cycles 7–9 involved practical investigation, testing, evidence recording, modification, and presentation.

The nine cycles were implemented from 24 November to 11 December 2025, over approximately three school weeks. The lesson plans specified a combined planned instructional time of 595 minutes (9 hours 55 minutes) across the nine activities, although actual classroom pacing could be adjusted when needed. The cycles were closely sequenced so that observations and practical issues from one activity could inform reflection and later adjustments while the classroom events remained recent.

Each cycle followed the AR process of planning, implementation, observation, and reflection (Kemmis et al., 2014). Classroom evidence was reviewed after implementation to identify difficulties and possible adjustments. Revision decisions were triggered by documented issues such as unclear instructions, repeated clarification needs, incomplete recording, language barriers, uneven participation, unsuitable materials, time pressure, or weak scientific explanation. Revisions could involve instructions, language and visual support, guiding questions, recording formats, materials, group organisation, activity procedures, or lesson time. The reasons for changes were recorded in observation/reflection records, field notes, teacher-researcher reflections, and cycle summaries. These cycle-level reviews supported practical refinement, while the complete dataset was analysed more systematically after the nine cycles.

Figure 3.1

Action Research as the Primary Inquiry Cycle and SAM as the Mechanism for Iterative Activity Refinement



Note. Action Research organised the classroom inquiry; SAM supported evidence-informed revision of activities and materials. Classroom evidence and documented reflection connected each cycle to the next.

Teacher guidance and language scaffolding remained available throughout the three phases. The amount and form of support were adjusted according to the activity and pupil needs. Accessible and low-cost materials were used where possible so that the activities could be carried out within the available school resources.

Table 3.1 summarises the nine Action Research cycles, including the activity focus, planned duration and materials, the main issue observed, and the reflection-informed adjustment made after each cycle.

Table 3.1

Overview of the Nine Action Research Cycles

Cycle / phase / Science focus	Planned duration and key materials	Main issue observed	Reflection-informed adjustment
C1 Survey - Toilet cleanliness / personal hygiene 24 Nov 2025	75 min; survey checklist, clipboards, chart paper, markers	Pupils were unfamiliar with inquiry routines; participation was cautious and some records were incomplete.	Retained simplified recording and guided questioning; strengthened peer discussion and reduced direct support where possible.
C2 Survey - Water	75 min; survey sheets,	Participation and recording	Maintained structured support

Cycle / phase / Science focus	Planned duration and key materials	Main issue observed	Reflection-informed adjustment
sources and uses 25 Nov 2025	clipboards, chart paper, markers	improved, although some pupils still required guidance.	while giving pupils greater responsibility for questioning, recording and discussion.
C3 Survey - Recyclable waste 26 Nov 2025	75 min; survey forms, clipboards, poster/chart paper, markers	Pupils worked more independently and some identified simple patterns, but support was still needed for explanation.	Retained scaffolding only where needed and moved towards tasks requiring more interpretation and problem solving.
C4 Case Study - Plant growth in sunny vs shady areas 1 Dec 2025	60 min; plants, ruler, observation sheet, clipboards	Responses were often descriptive; pupils needed prompts to explain causes and relationships.	Strengthened case prompts, structured analysis notes and group organisation.
C5 Case Study - Effects of acid on materials 2 Dec 2025	60 min; diluted vinegar/lemon juice, paper, metal, cloth, droppers, observation sheet	Interpretation improved, but some pupils still needed prompts to justify explanations.	Clarified the case-analysis sequence and retained structured prompts for evidence and reasoning.
C6 Case Study - Community flooding 4 Dec 2025	70 min; flood images, map/sketch, observation guide, poster materials	Pupils showed greater analytical independence, although English explanation remained difficult for some.	Maintained language and group support while preparing pupils for practical investigation.
C7 Experimental - Simple water filter 8 Dec 2025	65 min; bottles, sand, gravel, charcoal/cotton, muddy water, containers	Hands-on engagement was high, but some pupils could describe the result without explaining the filtration process.	Retained language and recording support; increased emphasis on prediction, comparison and scientific explanation.
C8 Experimental - Sink or float 9 Dec 2025	55 min; basin of water, selected objects, observation sheet	Pupils conducted tests more independently, but explanations remained uneven.	Retained recording/discussion prompts and placed greater emphasis on using evidence to explain results.
C9 Experimental - Simple electrical circuit 11 Dec 2025	60 min; battery, bulb, wires, optional switch	Groups troubleshoot loose or incorrect connections; some pupils explained a complete path, while others mainly described steps.	Used the final cycle evidence to refine explanation prompts, assessment guidance and practical implementation notes.

Note. Durations are the planned activity times specified in the SRA lesson plans; actual classroom pacing could be adjusted when required.

3.3. Data Collection and Analysis

Multiple sources of classroom evidence were collected across the nine Action Research cycles. Written pupil responses were obtained at relevant points using a semi-structured response protocol with simple wording and opportunities for clarification. Classroom observations were documented using observation and reflection records, while field notes recorded classroom events, practical difficulties, pupil reactions, instructional decisions and immediate teacher-researcher reflections. Pupil artefacts and activity outputs included survey records, worksheets,

written responses, research templates, practical investigation records and project outputs. Where continuous note-taking was not practical while teaching, field-note records were completed or expanded immediately after the lesson while the classroom events remained recent.

Table 3.2 summarises the data sources, their timing, purpose, and analytical use.

Table 3.2

Data Sources, Timing, Purpose and Analytical Use

Source	Timing	Purpose	Analytical use
Written pupil responses	Relevant points across phases and final review	Pupil experience, challenge, confidence, support, perceived learning	Thematic analysis and triangulation
Observation/reflection records	Every cycle	Participation, task completion, support needs, implementation difficulties	Within-cycle reflection and cross-cycle thematic comparison
Field notes	Every cycle; during or immediately after lessons	Chronological events, practical issues, teacher decisions	Reflection, audit trail and thematic analysis
Pupil artefacts/activity outputs	Relevant activity in each cycle	Recording, investigation, explanation and task evidence	Qualitative comparison and support for performance ratings
Teacher interviews	Baseline, selected implementation points and final review	Feasibility, classroom constraints, pupil response and revisions	Thematic analysis and triangulation
Cycle-level performance ratings	Every cycle	Engagement and activity-specific Learning Outcomes	Descriptive means and standard deviations

Table 3.3 provides an illustrative audit trail showing how selected raw evidence was coded and interpreted during the qualitative analysis.

Table 3.3

Illustrative Qualitative Audit Trail

Raw evidence	Initial code	Theme / pattern	Interpretation
"The most exciting activity is water survey." (EV29)	water survey exciting	Interest in contextual SRA activities	Evidence of positive engagement; not treated as achievement.
"It so challenging but also we can have fun." (EV31)	challenge and enjoyment	Productive challenge	Difficulty did not automatically prevent engagement when support was available.
"I can tell my teacher if I don't understand." (EV26)	support-seeking	Teacher support and confidence	Teacher mediation formed part of classroom usability.

Raw evidence	Initial code	Theme / pattern	Interpretation
Cycle 7: active filter construction, but some pupils described only that water was “cleaner” and could not explain particle trapping.	high practical engagement; weak mechanism explanation	Participation– understanding distinction	Hands-on success was not treated as sufficient evidence of scientific understanding.

The teacher-researcher was also interviewed at selected points using a semi-structured teacher interview protocol. A fellow teacher conducted these interviews. The questions addressed existing Science teaching practices, classroom constraints, the practicality of the SRA activities, pupil responses, instructional difficulties, changes made across the cycles and the overall usability of the guide. Interview records were analysed together with pupil responses, observations, field notes, artefacts and teacher-researcher reflections.

Pupil performance was assessed at cycle level using criteria aligned with the objectives, procedures, expected outputs and assessment focus of each SRA activity. Five criteria were used in each cycle. Two criteria assessed engagement, including participation in the activity and sustained involvement or contribution to group work. Three activity-specific criteria assessed learning outcomes, such as observation and recording, interpretation of evidence, scientific explanation, problem analysis, investigation or justification, depending on the objectives of the activity. Each criterion was rated on a four-point scale. Engagement therefore had a maximum score of 8 and Learning Outcomes a maximum score of 12.

Performance ratings were based on evidence generated during the SRA activities, including pupil work, activity outputs, classroom observation, task completion, investigation processes and pupil explanations or responses. Where activities involved group work, group outputs were considered together with individual participation, teacher observation and brief individual responses so that successful completion of a group task was not treated automatically as evidence of individual learning. Cycle-level Engagement and Learning Outcomes scores were analysed descriptively using means and standard deviations across the nine cycles and three instructional phases. The two dimensions were analysed separately because active participation did not necessarily indicate the same level of scientific understanding. Confidence was examined through qualitative responses and observations rather than treated as an achievement score. Learning Outcomes scores were interpreted in relation to the specific demands of each activity rather than as repeated administrations of the same achievement test.

Qualitative data were analysed using Braun and Clarke’s (2006) six-phase thematic analysis. The researcher first became familiar with the written responses, observation and reflection records, field notes, interview records and pupil artefacts. Initial codes were generated from features evident in the dataset, including engagement, collaboration, confidence, inquiry skills, language difficulties, dependence on teacher guidance, problems with instructions or materials, and required activity revisions. The coding was primarily inductive and data-led, while the organisation and comparison of codes were guided by the research objectives. Related codes were grouped into possible themes, reviewed against the coded extracts and wider dataset, combined or revised where necessary, and then defined and named. Analysis was conducted first within individual cycles and instructional phases and then across the nine cycles to identify recurring and contrasting patterns. Classroom performance ratings were interpreted alongside pupil artefacts, responses, observations, field notes, interview records and teacher reflections to support triangulation across evidence sources.

3.4. Trustworthiness and Ethical Considerations

Trustworthiness was supported through triangulation across different evidence sources, systematic documentation of classroom implementation and revisions, researcher reflexivity, clarification of participant responses where necessary, and description of the classroom context (Lincoln & Guba, 1985). Comparing pupil responses, observations, artefacts, performance records, field notes, and teacher interview records reduced reliance on a single source when interpreting recurring patterns. The teacher-researcher maintained reflexive notes after cycles to distinguish classroom evidence from her own expectations and to record reasons for instructional decisions. Selected

discussions with a critical friend were used to question interpretations and consider alternative explanations. The critical friend was consultative and did not act as an independent classroom observer, coder, or scorer. No independent second rater was used for the cycle-level performance ratings or pupil work, and this limitation is stated explicitly below.

The SRA activities formed part of normal Science instruction and were conducted with school-level administrative permission. The institutional documentation available for the study includes a research-administration completion record from Institut Pendidikan Guru Malaysia (IPGM), Ministry of Education Malaysia (LAM PT-10-02). The available record does not state a separate ethics approval/reference number, and no ethics approval number is therefore claimed in this article. Parents or guardians received information about the purpose of the study, the activities involved, the data collected, and the academic use of the findings, and consent was obtained before pupil data were included. Pupils were informed in age-appropriate language that participation in the research component was voluntary and that they could decline to provide responses or withdraw their data without academic penalty. A separate written pupil-assent form is not claimed.

Because the SRA activities formed part of normal Science instruction, withdrawal from the research component did not remove a pupil from classroom learning or normal assessment. A pupil could continue participating in the lesson while his or her research responses, ratings, or artefacts were excluded from the research dataset. Participant codes were used in the research records, identifying information was removed from reported responses and artefacts, and digital data were stored in password-protected files accessible only to the researcher.

4. Results

The results are presented in relation to the two research questions. Evidence from pupil responses, classroom observations, teacher interviews and reflections, field notes, pupil artefacts, activity outputs, and classroom performance records was considered across the nine Action Research cycles. The results are organised into three areas: classroom usability, pupil learning and participation, and the conditions affecting the instructional value of the SRA activities.

4.1. Classroom Usability of the SRA Activities

The SRA activities provided a workable structure for conducting research-based Science activities in the participating rural Year 5 ESL classroom. Usability depended on the combination of clear activity stages, structured recording formats, accessible materials, language support, teacher facilitation, and adjustment to classroom conditions.

Across the nine cycles, instructions, examples, grouping arrangements, materials, and lesson pacing were adjusted when pupils experienced difficulty. Low-cost and locally available materials allowed practical activities to be conducted without specialised equipment, although the materials still required preparation, testing, safety checks, and sharing between groups. Language support was also necessary. Simplified wording, visuals, sentence starters, structured formats, and bilingual clarification helped pupils understand tasks and communicate observations and ideas.

Teacher facilitation remained important throughout implementation. The teacher used explanation, targeted questioning, monitoring, demonstrations, and adjustable scaffolding according to the activity and pupils' needs. Although pupils took greater responsibility across the cycles, the guide did not operate independently of teacher judgement. Table 4.1 summarises the main dimensions of classroom usability observed during implementation.

Table 4.1*Classroom Usability of the SRA Activities*

Dimension	Evidence from implementation	Continuing condition
Classroom flexibility	Instructions, examples, grouping, materials, and pacing were adjusted during implementation.	Adaptation depended on teacher judgement and pupil readiness.
Materials and resources	Low-cost and locally available materials supported practical activities without specialised equipment.	Materials still required preparation, testing, safety checks, and group sharing.
Language support	Simplified wording, visuals, sentence starters, structured formats, and bilingual clarification supported task access.	Scientific explanation still required teacher questioning and conceptual support.
Teacher facilitation	Explanation, targeted questions, monitoring, demonstrations, and adjustable scaffolding were used.	Teacher guidance remained necessary when pupils experienced difficulty.
Pupil participation	Pupils became more willing to discuss, handle materials, record findings, and present group work.	Participation and confidence did not develop equally among all pupils.
Scientific explanation	Pupils increasingly used observations and evidence in their responses.	Some pupils could complete practical work but still needed support to explain the scientific result.

Overall, classroom usability was not determined by the written activities alone. The SRA structure supported implementation, but successful classroom use required continuing adjustment of language, materials, grouping, pacing, and teacher support.

4.2. Pupil Learning and Participation Across the SRA Phases

Pupil participation changed across the three instructional phases. During the Survey phase, pupils mainly practised questioning, observation, information gathering, and recording with considerable teacher guidance. Participation was initially cautious, and some pupils required repeated prompts or modelling before completing the activities.

During the Case Study phase, pupils took a more active role in examining situations, identifying problems, considering possible causes, and suggesting responses. Classroom evidence showed a gradual movement from simple description towards analysis and justification. Pupils also became more willing to discuss their ideas and participate in group work, although differences in English proficiency and confidence continued to affect participation.

The Experimental Science Activity phase placed greater responsibility on pupils. They planned, constructed or prepared materials, tested ideas, made observations, recorded evidence, modified their work where necessary, and presented their findings. Classroom observations showed high participation during hands-on activities. Group members increasingly shared tasks and assisted one another, and some groups adapted available materials when testing and improving their work.

The progression did not mean that pupils became fully independent by the final phase. Teacher support continued throughout the nine cycles, but its focus changed. Early support concentrated on explaining tasks and modelling procedures. During the Case Study phase, teacher questioning helped pupils distinguish between problems, causes, effects, and possible responses. During the Experimental Science Activity phase, teacher assistance focused more on materials, safety, procedural clarification, and connecting practical observations with scientific concepts.

Pupils also showed greater confidence and collaboration across the implementation period. They became more willing to contribute ideas, record findings, share responsibilities, and present group work. However, this development was not equal for all pupils. Some continued to require visual examples, structured prompts, language support, or encouragement to participate.

Written pupil responses provided complementary evidence of engagement, collaboration, and support-seeking. One pupil described the water survey as “The most exciting activity” (EV29), while another wrote, “It so challenging but also we can have fun” (EV31). A further response, “I can tell my teacher if I don’t understand” (EV26), showed that pupils recognised the role of teacher support. Another pupil wrote, “I usually groups for science activity because it’s interesting and cooperate” (EV31), illustrating the value placed on peer collaboration. These comments were interpreted as evidence of pupils’ experiences and engagement rather than as direct evidence of scientific achievement.

Cycle-level field notes and reflections also showed why particular adjustments were made. In Cycle 1, cautious participation and incomplete or inconsistent survey records led to the continued use of simplified recording formats and guided questioning in Cycle 2. In Cycle 7, reflection records showed strong hands-on participation but continuing difficulty in explaining the filtration process; Cycle 8 therefore retained language and recording support while placing greater emphasis on prediction, comparison and explanation.

The progression across the three phases is summarised in Figure 4.1.

Figure 4.1

Progression Across the Three SRA Phases

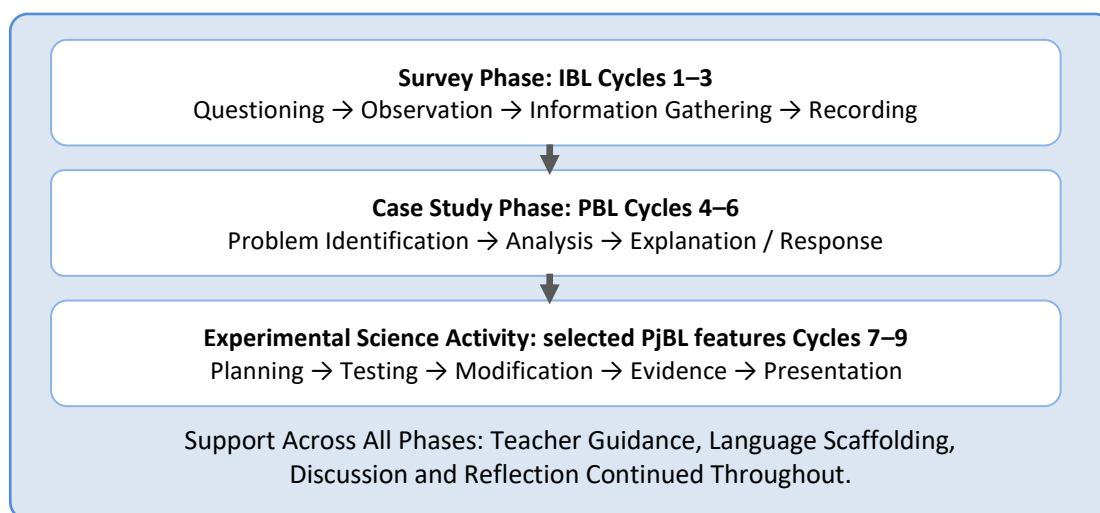


Table 4.2 summarises cycle-level classroom performance across the nine SRA cycles. Engagement and Learning Outcomes were reported separately so that active participation was not treated as equivalent to learning.

Table 4.2

Cycle-Level Classroom Performance across the Nine SRA Cycles

Cycle / SRA activity	Phase	Engagement M (SD) /8	Learning Outcomes M (SD) /12
C1 Toilet cleanliness	Survey	5.17 (1.37)	6.57 (1.75)
C2 Water sources	Survey	6.13 (1.42)	6.65 (1.75)
C3 Recyclable waste	Survey	6.61 (1.20)	7.52 (1.56)

Cycle / SRA activity	Phase	Engagement M (SD) /8	Learning Outcomes M (SD) /12
C4 Plant growth	Case Study	6.00 (1.35)	5.96 (1.74)
C5 Acid and materials	Case Study	6.39 (1.16)	6.43 (1.67)
C6 Community flooding	Case Study	6.70 (1.29)	7.00 (1.57)
C7 Water filtration	Experimental	7.17 (0.89)	5.35 (1.58)
C8 Sink or float	Experimental	6.91 (1.00)	6.57 (1.80)
C9 Electrical circuits	Experimental	7.43 (0.79)	7.57 (1.70)

Note. N = 23 for each cycle. Engagement was rated using two criteria (maximum = 8). Learning Outcomes were rated using three activity-specific criteria (maximum = 12). Scores are descriptive classroom-performance indicators and should be interpreted in relation to the objectives and demands of each activity. Confidence was examined qualitatively and was not treated as an achievement score. The cycle scores should not be interpreted as repeated administrations of the same achievement test.

Engagement showed a broad increase across the implementation period. The mean rose from 5.17/8 in Cycle 1 to 7.43/8 in Cycle 9. The pattern was not completely linear, but higher ratings were generally observed in the later cycles as pupils became more familiar with group discussion, task procedures, practical work, recording, and presentation.

Learning Outcomes showed greater variation because the activities required different forms of performance. During the Survey phase, the mean increased from 6.57/12 in Cycle 1 to 7.52/12 in Cycle 3. It declined to 5.96/12 in Cycle 4 when pupils moved to the more demanding Case Study phase, then increased to 6.43/12 in Cycle 5 and 7.00/12 in Cycle 6. A similar change occurred at the start of the Experimental Science Activity phase. The mean was 5.35/12 in Cycle 7, followed by 6.57/12 in Cycle 8 and 7.57/12 in Cycle 9.

Cycle 7 showed the clearest difference between engagement and learning. Engagement was high at 7.17/8, while the Learning Outcomes mean was 5.35/12. Classroom observations and pupil work showed that pupils participated actively in constructing and testing the water filters, but some had difficulty explaining the filtration process. This pattern supports the distinction between active participation and scientific understanding and shows why the two dimensions were examined separately.

Pupil work and classroom records also illustrated the changing demands across phases. Survey outputs included tally records and simple charts; Case Study work required pupils to organise evidence around problems, causes and possible responses; and Experimental Science Activity outputs included water filters, prediction-and-results records, and electrical circuits. The evidence also included incomplete or mixed performance. In Cycle 7, functioning filters sometimes coexisted with weak explanations of how particles were removed. In Cycle 9, several groups corrected loose or incorrect circuit connections, but some pupils could explain only the construction steps rather than why a complete path was required. These examples were retained in the analysis so that successful task completion was not treated as equivalent to conceptual understanding.

4.3. Conditions Affecting Instructional Value

The instructional value of the SRA activities depended on several classroom conditions. The first was language support. Pupils could sometimes complete an activity or practical procedure but still have difficulty explaining the scientific meaning of what they observed. Simplified instructions and bilingual clarification helped pupils access the tasks, but scientific explanation often required additional questioning, discussion, sentence support, and teacher prompts.

A second condition was the relationship between practical activity and reflection. Hands-on participation encouraged engagement, collaboration, and problem-solving, particularly during the Experimental Science Activity phase.

However, practical participation alone did not consistently produce clear scientific explanation. When lesson time became limited, the teacher had to avoid reducing or omitting the discussion and reflection stages because these stages helped pupils connect their observations with scientific concepts.

Materials and lesson time also affected implementation. The activities could be conducted using accessible materials, but preparation, organisation, safety checks, and material sharing still required teacher time. Different groups progressed at different rates, which affected the time available for recording, discussion, reflection, and presentation.

Group participation was another continuing issue. Collaboration became stronger across the phases, but some pupils remained more active than others. Structured group roles, teacher monitoring, and adjusted task organisation were therefore used to support more balanced participation.

These conditions indicate that the instructional value of the SRA activities came from the interaction between activity structure and classroom support. Figure 4.2 is a data-derived interpretive synthesis of recurring implementation conditions, presented as a practical framework rather than as a tested causal model. The conditions interacted in practice: for example, language support influenced how pupils used structured recording formats, teacher adaptation affected how materials and time were managed, and reflection helped connect hands-on participation with scientific explanation.

Figure 4.2

Conditions Supporting the Instructional Value of SRA in the Participating Classroom

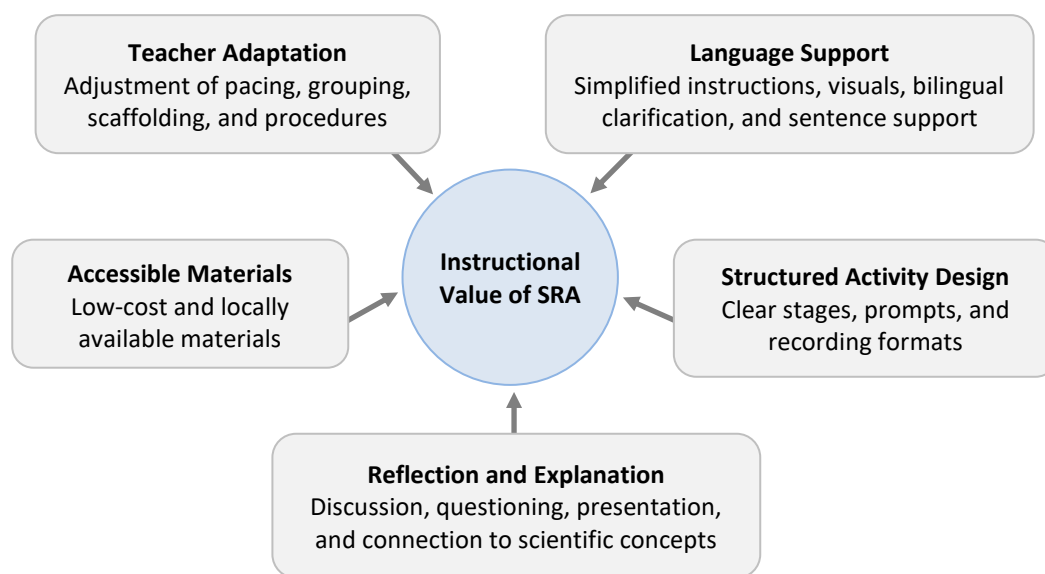


Figure 4.2 therefore summarises interacting conditions that supported classroom implementation in this study rather than independent variables with tested causal effects. The framework is context-specific and requires examination in other classrooms before broader claims can be made.

5. Discussion

The study examined the classroom usability of the SRA activities and the evidence of pupil learning and instructional value that emerged during implementation. Rather than restating the Results, the discussion focuses on what the observed patterns imply for research-based primary Science learning in a rural ESL context. The central interpretation

is that instructional value emerged from the combination of structured research-based activity, adaptive teacher mediation, language support, and protected opportunities for reflection and scientific explanation.

5.1. Structure, Teacher Adjustment and Classroom Usability

The SRA activities were usable because they provided pupils with clear stages, prompts, recording formats, and practical tasks while allowing the teacher to adjust pacing, grouping, language support, materials, and procedures. This finding is consistent with previous research showing that inquiry-based Science requires structured guidance rather than leaving pupils to manage open-ended activities independently (Alake-Tuenter et al., 2012; Kamarudin & Mat Noor, 2024; van Eijck et al., 2025). Kamarudin and Mat Noor (2024) also showed that primary Science inquiry depended on scaffolding, differentiation, pupils' prior knowledge, and opportunities to express and report ideas. Similarly, van Eijck et al. (2025) emphasised the need to connect practical activity with scientific reasoning, vocabulary, and conceptual understanding.

The findings also show that classroom usability was not a fixed property of the SRA guide. Instructions sometimes required clarification, while grouping, materials, and lesson pacing had to be adjusted during implementation. Similar practical and time-related challenges have been reported in enquiry-based primary Science classrooms (Greenwood et al., 2022; van Eijck et al., 2025). Teacher adjustment was therefore part of the implementation process rather than a departure from the guide. The structured activities provided a starting point, but teacher judgement remained necessary when pupils experienced difficulty or classroom conditions changed.

5.2. Pupil Participation and Scientific Understanding

Pupil participation became more active across the three SRA phases. Pupils gradually became more willing to discuss ideas, handle materials, record findings, share group responsibilities, and present their work. This pattern is consistent with research showing that inquiry and practical Science can encourage active participation, collaboration, and engagement among primary pupils (Bennett et al., 2023; Oguz-Unver & Yurumezoglu, 2014; Ogegbo et al., 2025). The progression from Survey to Case Study and Experimental Science Activity also allowed pupils to become familiar with basic research processes before taking greater responsibility for problem analysis and practical investigation.

However, greater participation did not always mean that pupils could explain the scientific ideas involved. Some pupils could complete practical procedures and describe what they observed but still required support to explain why a result occurred. This distinction between hands-on participation and scientific reasoning has also been reported in primary Science research (McCorry, 2018; van Eijck et al., 2025). Van Eijck et al. (2025) emphasised that hands-on activity needs to be connected with minds-on processes such as questioning, discussion, scientific vocabulary, and reasoning if practical experience is to contribute to conceptual understanding.

The findings therefore support the continued use of discussion, teacher questioning, structured recording, presentation, and reflection after practical activity. These processes can help pupils move from completing a task towards interpreting observations and explaining them scientifically (Cabello et al., 2021; van Driel et al., 2018; van Eijck et al., 2025). This is important because scientific explanation requires pupils to connect evidence with scientific ideas rather than simply report what they observed (Cabello et al., 2021).

5.3. Rural ESL Conditions and Instructional Value

The instructional value of the SRA activities was closely related to the rural and ESL conditions of the classroom. Limited resources did not prevent practical Science learning, but they affected how activities had to be organised. Low-cost and locally available materials made the activities more feasible, while preparation, safety, sharing of materials, and differences in group pace still required teacher attention. Similar concerns have been reported in rural Science education, where teaching approaches often need to be adapted to local resources and classroom conditions (Aidoo, 2024; Iturbe-Sarunic et al., 2026; Mat Noor, 2022).

The ESL context also affected how pupils participated in the activities. Simplified instructions, visuals, bilingual clarification, sentence support, and teacher questioning helped pupils understand tasks and communicate their observations. This is consistent with research showing that language can affect pupils' participation and understanding in rural Malaysian classrooms (Rupiwini & Shah, 2021; Yunus & Jong, 2016) and that Science learning requires planned support for scientific vocabulary and explanation (Bennett et al., 2023; van Driel et al., 2018).

The findings further suggest that language support was needed not only for understanding instructions but also for explaining scientific meaning. Some pupils could complete practical work successfully but still needed help to describe relationships, justify conclusions, or connect observations with scientific concepts. Similar difficulties have been reported when pupils move from hands-on participation to scientific explanation (Cabello et al., 2021; van Eijck et al., 2025). This reinforces the importance of combining accessible tasks with continued language and conceptual support rather than treating practical participation as sufficient evidence of understanding (Bennett et al., 2023; van Driel et al., 2018; van Eijck et al., 2025).

5.4. Interpreting Evidence of Learning

Cycle-level classroom performance provided a more detailed view of pupil development across the implementation period. Engagement showed a broad increase across the nine cycles, while Learning Outcomes varied with the demands of each activity. The changes were therefore interpreted as patterns of classroom performance across the Action Research process rather than as a single before-and-after measure of achievement.

The Learning Outcomes pattern also showed that development was not linear. Ratings increased within the Survey and Case Study phases, but declined when pupils moved into tasks that required different forms of analysis or explanation. The lower Learning Outcomes rating in Cycle 7, despite high engagement, was consistent with classroom evidence showing that pupils could participate successfully in constructing and testing a filter while still needing support to explain the scientific process. This distinction is consistent with research showing that practical participation needs to be connected with evidence, reasoning, and scientific explanation (Bennett et al., 2023; van Eijck et al., 2025).

The cycle-level ratings converged with qualitative evidence of participation, confidence, collaboration, and growing familiarity with research-related processes such as questioning, observation, problem analysis, practical investigation, evidence recording, and presentation. Confidence was treated as an experiential/affective pattern rather than proof of achievement. The mixed cycle pattern, especially Cycle 7, shows why classroom performance, engagement, confidence, and scientific understanding need to be interpreted as related but distinct forms of evidence.

5.5. Practical Contribution and Implications

For teacher education and professional development, the findings suggest that support for rural primary Science teachers should address adaptive scaffolding, low-cost practical work, scientific-language support, formative classroom assessment, and the use of reflection to connect practical activity with explanation. Professional learning should therefore focus on teacher decision-making during implementation rather than only on providing activity sheets.

At school level, implementation also depends on practical resource planning. Leadership support for preparation time, storage and replenishment of low-cost materials, printing or recording resources, and collaborative planning can make locally adaptable research-based activities easier to sustain. These implications extend beyond the individual teacher while remaining propositions from one classroom rather than tested system-level effects.

The practical contribution of the study lies in the classroom-tested organisation and refinement of the three activity types rather than in proposing a new learning theory or claiming universal effectiveness. The SRA sequence provides a structured way to connect guided inquiry, contextual problem analysis, and practical investigation in a rural ESL primary Science setting, while the nine Action Research cycles show how that structure required adjustment during

classroom use. The findings also have several practical implications for teachers who use research-based Science activities in similar settings. First, activities should provide a clear structure while allowing teachers to adjust instructions, pacing, grouping, materials, and scaffolding according to pupil needs. This recommendation is consistent with Alake-Tuenter et al. (2012) and Kamarudin and Mat Noor (2024), who emphasised the importance of teacher guidance, scaffolding, and adaptation in inquiry-based Science. A fixed sequence may provide consistency, but effective classroom use still requires teacher judgement.

Second, language support should be planned as part of the Science activity rather than added only when pupils experience difficulty. Simplified instructions, visuals, bilingual clarification, sentence support, and teacher questioning can help pupils understand tasks and communicate their observations. However, support should also extend to scientific explanation so that pupils can move beyond completing procedures to explaining what their evidence means.

Third, discussion and reflection should remain part of practical activities even when lesson time is limited. The findings showed that hands-on participation alone did not always lead to clear scientific explanation. This is consistent with Bennett et al. (2023) and van Eijck et al. (2025), who stressed the need to connect practical activity with reasoning, discussion, and conceptual understanding. Teachers therefore need to protect time for pupils to discuss observations, record evidence, answer guiding questions, and explain conclusions.

Finally, the use of low-cost and locally available materials can make research-based Science activities more feasible in schools with limited resources. However, teachers still need to consider preparation, safety, material sharing, and differences in group progress. The SRA guide should therefore function as practical support for teacher decision-making rather than as a fixed set of procedures to be followed without adjustment.

5.6. Limitations and Future Research

Several limitations should be considered when interpreting the findings. The study involved one intact Year 5 class of 23 pupils in a single rural primary school, so the findings are specific to the participating classroom and should not be generalised to all rural or ESL settings. The teacher also served as the researcher, which allowed close observation across the nine cycles but may have influenced classroom interpretation and evaluation. Reflexive notes, triangulation, and critical-friend discussion reduced reliance on personal impressions, but no independent classroom observer, second qualitative coder, or independent performance scorer was used. English proficiency and prior Science achievement were not independently standardised, which also limits more detailed subgroup interpretation.

The study did not include a comparison group. The cycle-level performance ratings were descriptive and the Learning Outcomes criteria reflected the objectives of each activity. They should therefore not be interpreted as repeated measures of a single achievement construct or as evidence of causal effects. The SRA guide also evolved during the nine Action Research cycles. This responsiveness is a methodological strength for improving practice under authentic conditions, but it limits any claim about the effect of one fixed, unchanged treatment.

Future research could examine the SRA approach with other teachers, schools, pupil groups, and resource conditions to determine how well it can be adapted beyond the participating classroom. Comparative or larger-scale studies could also provide stronger evidence about learning outcomes, while further classroom-based research could examine how teacher guidance, language support, and different levels of scaffolding affect pupils' scientific reasoning and independence.

6. Conclusion

This study examined the implementation of Science Research-Based Activities (SRA) in a rural Year 5 ESL classroom in Sarawak. The findings showed that the activities provided a workable structure for research-based Science learning when clear activity stages, language support, accessible materials, teacher adjustment, and opportunities for discussion and reflection were available.

Across the three SRA phases, pupils became more familiar with questioning, observation, information gathering, problem analysis, practical investigation, evidence recording, collaboration, and presentation. Cycle-level classroom performance showed a broad increase in engagement, while learning-related performance varied according to the demands of each activity and generally improved within the three phases. The findings also showed that active participation did not always coincide with scientific explanation, particularly during hands-on activities.

The study shows that the instructional value of SRA depended on both the activity structure and the conditions of classroom implementation. Its scholarly contribution is a context-sensitive implementation proposition: structured research-based activity, adaptive scaffolding, language support, accessible materials, and reflection/explanation worked together to support instructional value in this classroom. This proposition is derived from one setting and requires further testing. The SRA guide should therefore remain described as a refined and classroom-tested prototype rather than a new theory, a universally superior pedagogy, or a validated programme for all settings.

Declarations

Acknowledgements

The authors used OpenAI's ChatGPT (GPT-5.6 Sol) to assist with language editing, manuscript organisation, and citation checking. All AI-assisted outputs were reviewed, revised, and verified by the authors, who take full responsibility for the final manuscript.

Competing Interests

None.

Ethical Approval

Approval to conduct the study was obtained from the relevant educational authorities and the school administration before data collection. Parents or guardians received information about the study, and informed consent was obtained before pupil data were included. Pupils were informed in age-appropriate language that participation in the research was voluntary.

Author Contributions

Su Shiang Wong: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Writing – original draft

Pik Kuong Ling: Supervision, Writing – review and editing

References

- Aidoo, B. (2024). A reflective study on adopting inquiry-based science teaching methods. *Disciplinary and Interdisciplinary Science Education Research*, 6, Article 29. <https://doi.org/10.1186/s43031-024-00119-3>
- Alake-Tuenter, E., Biemans, H. J. A., Tobi, H., Wals, A. E. J., Oosterheert, I., & Mulder, M. (2012). Inquiry-based science education competencies of primary school teachers: A literature study and critical review of the American National Science Education Standards. *International Journal of Science Education*, 34(17), 2609–2640. <https://doi.org/10.1080/09500693.2012.669076>
- Aldea, K. Q., & Dayawon, M. A. (2025). Rural science education during and beyond COVID-19: Teachers' strategies and prospects from a Philippine perspective. *International Journal of Evaluation and Research in Education*, 14(4), 2846–2856. <https://doi.org/10.11591/ijere.v14i4.30446>

- Allen, M. W., & Sites, R. (2012). *Leaving ADDIE for SAM: An agile model for developing the best learning experiences*. ASTD Press.
- Bennett, J. M., Dunlop, L., Atkinson, L., Compton, S., Glasspoole-Bird, H., Lubben, F., Reiss, M. J., & Turkenburg-van Diepen, M. (2023). *A systematic review of approaches to primary science teaching*. Education Endowment Foundation. <https://educationendowmentfoundation.org.uk/education-evidence/evidence-reviews/primary-science>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Cabello, V. M., Moreira, P. M., & Griño Morales, P. (2021). Elementary students' reasoning in drawn explanations based on a scientific theory. *Education Sciences*, 11(10), Article 581. <https://doi.org/10.3390/educsci11100581>
- Greenwood, R., Austin, S., Bacon, K., & Pike, S. (2022). Enquiry-based learning in the primary classroom: Student teachers' perceptions. *Education 3-13*, 50(3), 404–418. <https://doi.org/10.1080/03004279.2020.1853788>
- Iturbe-Sarunic, C., Merino, C., & Miller, B. G. (2026). A systematic review of rural science education: Key ideas for designing teaching and learning sequences. *Journal of Technology and Science Education*, 16(1), 47–67. <https://doi.org/10.3926/jotse.3156>
- Kamarudin, M. Z., & Mat Noor, M. S. A. (2024). What do we know about the selection of action research methodologies in primary science education? A systematic literature review. *Educational Action Research*, 32(5), 825–847. <https://doi.org/10.1080/09650792.2023.2261502>
- Kemmis, S., McTaggart, R., & Nixon, R. (2014). *The action research planner: Doing critical participatory action research*. Springer. <https://doi.org/10.1007/978-981-4560-67-2>
- Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. SAGE.
- Mat Noor, M. S. A. (2022). An insight into primary science education in Malaysia. *ASE International*, 16, 34–41. <https://eprints.whiterose.ac.uk/208367/>
- McCorry, A. (2018). Scientific enquiry and engaging primary-aged children in science lessons (Part 2): Why teach science via enquiry? *Journal of Emergent Science*, 14, 28–39.
- Ogegbo, A. A., Upahi, J. E., Ramnarain, U., & Wu, H.-K. (2025). A systematic review on assessment in inquiry-based science education. *International Journal of Research in STEM Education*, 7(1), 71–91. <https://doi.org/10.33830/ijrse.v7i1.1744>
- Oguz-Unver, A., & Yurumezoglu, K. (2014). Primary science students' approaches to inquiry-based learning. *International Online Journal of Primary Education*, 3(2), 76–84.
- Ölçer, S. (2025). Inquiry-based science teaching in primary school. *Journal of Child Development and Education*, 1(1), 55–66.

- Rupiwin, F., & Shah, P. M. (2021). Malaysian rural primary school students' perceptions of experiences towards second language learning. *International Journal of Academic Research in Business and Social Sciences*, 11(9), 68–96. <https://doi.org/10.6007/IJARBS/v11-i9/10675>
- Uluçınar, U. (2023). The effect of problem-based learning in science education on academic achievement: A meta-analytical study. *Science Education International*, 34(2), 72–85. <https://doi.org/10.33828/sei.v34.i2.1>
- van Driel, S., Slot, E., & Bakker, A. (2018). A primary teacher learning to use scaffolding strategies to support pupils' scientific language development. *European Journal of STEM Education*, 3(2), Article 5. <https://doi.org/10.20897/ejsteme/3115>
- van Eijck, T., Bredeweg, B., Holt, J., Pijls, M., Bouwer, A., Hotze, A., Louman, E., Ouchchahd, A., & Sprinkhuizen, M. (2025). Combining hands-on and minds-on learning with interactive diagrams in primary science education. *International Journal of Science Education*, 47(18), 2413–2433. <https://doi.org/10.1080/09500693.2024.2387225>
- Yunus, M. M., & Jong, S. C. (2016). Teachers' perspective on the reading behaviour of primary ESL learners in SJKC Chung Hua Semera Sarawak. *Proceedings of the ICECRS*, 1(1), 493–498. <https://doi.org/10.21070/picecrs.v1i1.518>
- Zhou, Y., Jantharajit, N., & Srikhao, S. (2025). Integrating inquiry-based and project-based learning: A new model to enhance students' teamwork, skills, and critical thinking. *Journal of Education and Educational Development*, 12(2), 215–237. <https://doi.org/10.22555/joeed.v12i2.1340>