Implementation of the Learning Station Technique Based on Tomlinson's Differentiated Instruction Framework to Enhance Year 5 Pupils' Science Experimentation Skills

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ABSTRACT

We conducted a qualitative case study to examine how Learning Stations based on Tomlinson's Differentiated Instruction Framework impact the Science experimentation skills of Year 5 pupils. Many primary school pupils struggle with basic practical skills, particularly when handling equipment or writing clear inferences. To address this, we focused on 20 Year 5 pupils from a national primary school in Malacca. We collected data through structured classroom observations, pupils' practical worksheets, and semi-structured interviews. Our findings reveal that rotating through targeted stations helped pupils develop disciplined psychomotor control of science tools and articulate logical, evidence-based inferences. Rather than acting as passive observers, pupils engaged directly with practical tasks tailored to their readiness levels. These results indicate that incorporating differentiated learning stations offers a practical pathway for primary science teachers to move away from rigid, teacher-led practical sessions.

Keywords: Learning Stations, Differentiated Instruction, Science Process Skills (SPS), Experimentation Skills, Qualitative Case Study, Tomlinson.

INTRODUCTION

Hands-on practical work forms the backbone of primary science education, helping pupils build core Science Process Skills (SPS). The Primary School Science Standard Curriculum and Assessment Document (DSKP) emphasizes that mastering these skills allows young learners to conduct meaningful scientific inquiries. In reality, however, many pupils in everyday classrooms still struggle when handling basic lab equipment or making sense of what they observe during experiments.

Traditional, one-size-fits-all teaching explains much of this gap. When a whole class follows identical steps at the exact same pace, pupils who need more time often feel overwhelmed, while fast learners quickly get bored. Differentiated instruction provides a clear way forward. Using Tomlinson's (2014) framework within structured Learning Stations allows teachers to tailor content, processes, and tasks to match different readiness levels. This study explores how 20 Year 5 pupils in Malacca engaged with station-based practicals, looking specifically at their tool handling and ability to construct inferences.

Background & Problem Statement

Science education today places strong emphasis on critical thinking, problem-solving, and student-centered inquiry. Mastering Science Process Skills (SPS)—especially psychomotor skills like tool manipulation and cognitive skills like inference construction—helps primary pupils develop a genuine scientific mindset (Osman et al., 2021). These skills allow young learners to approach experiments with confidence and structure.

In reality, many Year 5 pupils encounter major hurdles during practical work. They often struggle to handle apparatus correctly and find it difficult to write clear, logical inferences from their observations. In our baseline

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sessions, we observed pupils hesitating over basic measuring tools, making simple technical errors like misreading liquid levels, and waiting constantly for step-by-step teacher instructions. When analyzing their data, most pupils failed to link variables with outcomes, producing vague or scientifically weak conclusions.

Conventional whole-class teaching tends to worsen these issues. Rigid, one-size-fits-all practical sessions ignore differences in student readiness and learning styles. While struggling learners quickly feel overwhelmed by identical tasks, high achievers finish early and lose focus. As a result, many pupils become passive onlookers rather than active participants in group lab work (Bahrum et al., 2020).

Left unaddressed, these learning gaps hold pupils back from developing core scientific competencies. Exploring how differentiated Learning Stations can tackle these hands-on struggles provides valuable insights for primary science classrooms across Malaysia.

Research Objectives & Questions

Overall, this qualitative case study aims to explore the effectiveness of the Learning Station technique based on Tomlinson's Differentiated Instruction Framework (2014) in enhancing Year 5 pupils' Science experimentation skills. Focus is directed toward three main dimensions: apparatus handling, logical inference construction, and active pupil engagement.

Table 1: Mapping of Research Objectives and Research Questions

Research Objectives	Research Questions
1. To explore Year 5 pupils' mastery in handling science apparatus systematically during practical activities via Tomlinson's differentiated Learning Station technique (2014).	1. How does the implementation of the differentiated Learning Station technique help Year 5 pupils systematically handle science apparatus?
2. To understand Year 5 pupils' ability to construct logical inferences based on practical observations via Tomlinson's differentiated Learning Station technique (2014).	2. How does the implementation of the differentiated Learning Station technique help Year 5 pupils construct logical inferences based on practical observations?
3. To identify changes in Year 5 pupils' engagement and motivation while participating in inquiry activities via the differentiated Learning Station technique.	3. How does the implementation of the differentiated Learning Station technique influence Year 5 pupils' engagement and motivation during Science inquiry activities?

Significance of the Study

Beyond expanding qualitative research in primary science, this study offers practical value across several key areas in education:

For Pupils: Rather than struggling through uniform practical sessions, pupils develop experimentation skills in a flexible learning space designed around their readiness and learning profiles. This approach builds confidence, making apparatus handling and inference building far less intimidating.

For Science Teachers: Running differentiated activities in a lab can seem daunting. The findings provide teachers with a tested, station-based guide for managing mixed-ability classes without adding excessive prep work.

For School Administrators: School leaders gain concrete insights into how science lab spaces can be organized for station rotation. These findings also help administrators plan targeted professional development sessions for science staff.

For Policy Makers (MOE/BPK/IPG): For curriculum designers and teacher trainers, this study provides real-world evidence from Malaysian primary labs. These insights can help refine pedagogical guides for KSSR Science and strengthen pre-service training modules at Teacher Education Institutes (IPG).

Operational Definitions & Limitations

Operational Definitions

- **Learning Station Technique:** The division of the Year 5 Science laboratory into three physical stations (Station 1: Apparatus/Psychomotor, Station 2: Inference/Cognitive, and Station 3: Application/Inquiry). Pupils rotate in small groups across stations within a 60-minute lesson block.
- **Tomlinson's Differentiated Instruction Framework:** A pedagogical model based on **Tomlinson (2014)** modifying *Content* (differentiated worksheets), *Process* (guided visual cue cards), *Product* (flexible reporting formats), and *Environment* (collaborative station layouts for 4-5 pupils) based on readiness and learning profiles.
- **Science Experimentation Skills:** Mastery focused specifically on two key domains in Year 5 Science topics: handling apparatus (psychomotor domain: holding, measuring, cleaning apparatus) and constructing logical inferences (cognitive domain: stating reasonable causes based on practical data).
- **Year 5 Pupils:** The target group of 20 Level 2 primary pupils in a National School in Malacca learning under the Revised KSSR Science Curriculum.

Research Limitations

This study uses a qualitative case study design focused on 20 Year 5 pupils at a national primary school in Alor Gajah, Malacca. As with most qualitative research, these findings are not meant to be statistically generalized to all Year 5 pupils across Malaysia (Merriam & Tisdell, 2016). Rather, the goal is to provide a detailed, contextual understanding of how Tomlinson's differentiated Learning Stations function in an everyday classroom setting.

To keep the analysis thorough, we limited the study's scope to two specific Science Process Skills: handling apparatus and formulating logical inferences. We also addressed potential observer bias and the Hawthorne Effect by spending time acclimating pupils to our presence before data collection and maintaining ongoing researcher reflexivity throughout the process.

LITERATURE REVIEW & THEORETICAL FRAMEWORK

Primary science education emphasizes a balanced integration of cognitive thinking and psychomotor skills (**Abdullah et al., 2017**). Experimentation skills involve pupils' capacity to plan, execute, and evaluate scientific investigations. Mastering manipulative skills—such as selecting and handling tools, sketching specimens, and cleaning apparatus safely—is fundamental to obtaining reliable experimental data.Tomlinson’s Differentiated Instruction Theory (2014)

Tomlinson’s Differentiated Instruction Framework Differentiated Instruction (Tomlinson, 2014) provides the main theoretical footing for this study. Rather than assuming all students learn at the same pace or in the same way, Tomlinson suggests adapting classroom practice around three core student characteristics: readiness, interest, and learning profile. In a practical science setting, readiness can be supported through tiered tasks—such as offering illustrated guide cards for students who struggle with tool handling while providing open-ended challenges for high achievers. By adjusting content, process, product, and learning environment, station-based activities create a more flexible space where students with varying abilities can achieve core learning goals.

Integrated Review of Past Studies

The literature review analyzed local and international empirical studies supporting learning stations and Tomlinson’s differentiated instruction:

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Table 2: Analysis of Local and International Literature

Author & Year	Title & Key Findings	Limitations & Research Gap
Siti Rahaimah et al. (2022)	Differentiated instruction in mixed-ability science classrooms. Differentiated product options bridged gaps across tiers; lower-readiness pupils felt supported while high-achievers tackled HOTS tasks.	Small sample size restricted to a few schools in a single district.
Suaibatul Aslamiah & Hanafi (2021)	Effectiveness of Tomlinson's differentiation on science achievement. Modifying content and process significantly enhanced conceptual understanding.	Quantitative focus on written tests; lacked qualitative investigation into practical behavioral shifts.
Mavidou & Kakana (2019 - Greece)	Differentiated instruction through learning centers/stations. Stations were the most effective vehicle for Tomlinson's theory, fostering learner autonomy.	Required extensive physical and material preparation prior to lessons.
Bulunuz et al. (2016 - Turkey)	Effects of hands-on science stations on primary students. Practical stations significantly boosted SPS and core concept mastery compared to traditional delivery.	Limited strictly to specific physical science topics.

Research Gap

While existing local studies have examined differentiated instruction, most rely on quantitative tests to measure conceptual knowledge. Very few qualitative studies have investigated how station-based differentiation directly changes primary pupils' practical behaviors—specifically their apparatus handling and cause-and-effect inferencing—during regular science lab sessions in Malaysia.

RESEARCH METHODOLOGY

Research Design

This study employs a qualitative approach using a **case study design** (**Creswell & Creswell, 2023**; **Yin, 2018**). Qualitative inquiry allows researchers to explore dynamic lab environments in depth. A case study design is particularly appropriate for examining a bounded system—specifically a cohort of 20 Year 5 pupils in a National Primary School in Malacca.

Differentiated Learning Station Intervention Procedure

The intervention was executed using a station rotation model across three main stations aligned with Tomlinson's (2014) framework:

Table 3: Differentiated Science Learning Station Implementation Matrix

Station	**Activity Focus & Tomlinson Elements**	**Qualitative Data Collected**
Station 1: Basic Exploration (10 Mins)	Identification of tools and functions. *Content* Element (Tiered visual step cards tailored to readiness levels).	Apparatus check-list & field notes.
Station 2: Practical & Manipulation (13 Mins)	Kinesthetic manipulation, operating measuring cylinders & balances. *Process* Element (Hands-on & visual scaffolding).	Structured apparatus manipulation observation forms.

Station 3: Inference & Challenge (10 Mins)	Data analysis & logical inference construction. *Product* Element (Flexible reporting formats & HOTS tasks).	Practical worksheets & semistructured interviews.

Population & Study Sample

The population comprised Year 5 pupils at a National School in Malacca. Using *purposive sampling*, 20 pupils were selected as participants. Selection criteria were based on pre-intervention diagnostic assessments and teacher observations indicating pronounced weaknesses in handling apparatus systematically and constructing logical inferences (**Miles et al., 2014**).

Triangulation of Data Collection Instruments

To ensure data validity through method triangulation (**Merriam & Tisdell, 2016**), three primary qualitative instruments were deployed:

1. **Structured Observation Forms:** Recorded apparatus handling behaviors (scale 1: Full Support Needed, 2: Minimal Support Needed, 3: Independent), inference formulation, and active engagement directly in real time.

2. **Document Analysis (Practical Worksheets):** Analyzed written inference quality, variable reasoning, and data accuracy using an SPS rubric.

3. **Semi-Structured Interview Protocols:** Explored pupils' verbal perceptions, affective motivation, and experiences within differentiated stations (15-20 minute audio recordings).

Trustworthiness, Ethics & Verification

Data validity was established via triangulation, member checking, and expert validation of modules and instruments (**Lincoln & Guba, 1985**). Dependability was preserved through audit trails tracking thematic coding. Research ethics were upheld by obtaining Parent/Guardian Consent, anonymizing pupil identities using codes M1–M20, and securing Official School Research Approval (SKDT 001(1)).

FINDINGS & DISCUSSION

Participant Demographic Profile (N = 20)

This section outlines baseline profile data for the 20 Year 5 pupils from SK Durian Tunggal, Malacca. Anonymous coding from M1 to M20 is used to maintain strict confidentiality:

Table 4: Participant Profile Matrix (M1 - M20)

Code	Gender	Baseline SPS Readiness	Learning Profile (Tomlinson)	Initial Learning Station Group
M1	Male	Low	Visual / Kinesthetic	Intensive Support Station (High Scaffolding)
M2	Female	Moderate	Visual / Auditory	Intermediate Station (Moderate Scaffolding)
M3	Male	High	Kinesthetic	Enrichment Station (Self-Directed Inquiry)

M4	Female	Low	Visual	Intensive Support Station (High Scaffolding)
M5	Male	Moderate	Auditory / Verbal	Intermediate Station (Moderate Scaffolding)
M6	Female	High	Visual / Kinesthetic	Enrichment Station (Self-Directed Inquiry)
M7	Male	Low	Kinesthetic	Intensive Support Station (High Scaffolding)
M8	Female	Moderate	Visual	Intermediate Station (Moderate Scaffolding)
M9	Male	Moderate	Kinesthetic / Auditory	Intermediate Station (Moderate Scaffolding)
M10	Female	High	Visual	Enrichment Station (Self-Directed Inquiry)
M11	Male	Low	Kinesthetic	Intensive Support Station (High Scaffolding)
M12	Female	Moderate	Auditory	Intermediate Station (Moderate Scaffolding)
M13	Male	High	Visual / Kinesthetic	Enrichment Station (Self-Directed Inquiry)
M14	Female	Low	Visual	Intensive Support Station (High Scaffolding)
M15	Male	Moderate	Kinesthetic	Intermediate Station (Moderate Scaffolding)
M16	Female	Moderate	Visual / Auditory	Intermediate Station (Moderate Scaffolding)
M17	Male	High	Kinesthetic	Enrichment Station (Self-Directed Inquiry)
M18	Female	Low	Auditory / Visual	Intensive Support Station (High Scaffolding)
M19	Male	Moderate	Kinesthetic	Intermediate Station (Moderate Scaffolding)
M20	Female	High	Visual / Kinesthetic	Enrichment Station (Self-Directed Inquiry)

Theme 1 Findings: Mastery of Science Process Skills (SPS)

1. Competency in Handling Science Apparatus

Structured observation field notes demonstrated that process differentiation tailored to student readiness significantly boosted psychomotor confidence. Lower-readiness pupils (M1, M4, M7, M11), who initially appeared hesitant and awkward handling tools, achieved disciplined execution after referencing visual cue cards:

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> *"M1 and M7 appeared hesitant during the first 5 minutes at Station 1. However, after referring to the differentiated visual step card and receiving teacher guidance, M1 successfully read the liquid meniscus level accurately without spilling."* ***[Observation Field Notes / Station 1 / Session 2]***

Semi-structured interview data confirmed that tiered visual prompts alleviated pupils' anxiety regarding glass apparatus:

> *"Previously, I was scared of using the measuring cylinder because I thought it would break. But at this station, there were step-by-step pictures, so I learned how to hold it properly and read the water level correctly."* ***[Interview / M4 / L12]***

2. Construction of Logical and Precise Inferences

Customizing materials to match learning profiles enabled pupils to analyze relationships between variables and observations. Document analysis of practical worksheets revealed that high- and mid-tier pupils articulated precise scientific reasons grounded in concrete experimental evidence:

> *"The rate of water evaporation is faster at Station A compared to Station B because the surface area of the container used is larger."*
>
> ***[Practical Worksheet / M3 / Station 3]***
>
> *"The plant at Station X wilted because it did not receive an adequate water supply compared to the plant at Station Y."* ***[Practical Worksheet / M12 / Station 2]***

Interview responses from M9 demonstrated that peer interactions at stations helped clarify the distinction between descriptive observations and logical inferences:

> *"I used to confuse observations with inferences. At this station, when discussing with friends and manipulating real materials, I realized that an inference explains the reason or cause behind an observation."*
>
> ***[Interview / M9 / L24]***

Theme 2 Findings: Student Engagement and Motivation

1. Cultivating Active and Focused Learning

Differentiated stations significantly reduced classroom monotony through rotated tasks. Observation notes recorded a distinct behavioral shift in M15 (moderate tier), transitioning from passive sitting in traditional lessons to active data collection at the kinesthetic station:

> *"M15 (who is typically passive during teacher-centered instruction) was highly active organizing apparatus and recording readings at the Kinesthetic Station, voluntarily taking the role of group data collector."* ***[Observation Field Notes / Station 3 / Session 4]***
>
> *"I really enjoy learning like this because I don't feel bored sitting in one chair all the time. We get to move between stations and do hands-on experiments with our teammates."*
>
> ***[Interview / M15 / L08]***

2. Fostering Self-Directed Inquiry Motivation (Respectful Tasks)

Applying Tomlinson's respectful tasks instilled intrinsic drive. High-readiness pupils (M3, M13) voluntarily requested extra challenge sheets at the Enrichment Station without prompting:

> *"M3 and M13 requested additional challenge task sheets at Station 4 to test their secondary hypothesis independently without being asked by the teacher."*

[Observation Field Notes / Station 4 / Session 3]

Qualitative Data Triangulation Matrix

Mapping qualitative data from three sources (Observation, Worksheets, and Interviews) confirms the validity of the case study findings in Table 5:

Table 5: Data Triangulation Matrix by Theme and Qualitative Source

Main Theme	Observation Field Notes	Document Analysis (Worksheets)	Pupil Interview Transcripts
Apparatus Handling (Psychomotor SPS)	Supported pupils (M1, M7) read liquid meniscus correctly without spills after using visual step cards.	Manipulative rubric scores improved from Level 1 (Full Support) to Level 3 (Independent).	"I learned how to hold it properly and read the water level correctly" (M4).
Logical Inference (Cognitive SPS)	Pupils actively connected variables at Station 2 using concrete objects during peer discussions.	Precise scientific written inferences backed by empirical evidence (M3, M12).	"I realized that an inference explains the reason behind an observation" (M9).
Engagement & Motivation	M15 actively logged data; M3/M13 initiated requests for extra HOTS challenge tasks.	Enrichment worksheets completed voluntarily by high-tier learners.	"Don't feel bored sitting in one chair... satisfied completing tasks myself" (M2, M15).

Intellectual Synthesis & Discussion

The clear gains in how pupils handled equipment and structured their written inferences support Tomlinson's (2014) core idea: students perform better when instruction adapts to their readiness levels. Providing step-by-step visual cards at Station 1 significantly reduced practical anxiety among lower-readiness pupils. Learners who initially hesitated to handle measuring cylinders began taking accurate meniscus readings once given clear visual guidance.

Rotating through stations that accommodated visual, auditory, and kinesthetic preferences allowed pupils to grasp concepts through hands-on experience before putting their explanations into writing. Step-by-step scaffolding kept tasks within the pupils' Zone of Proximal Development. Furthermore, using "respectful tasks"—where every group faced an appropriately challenging activity—prevented the off-task behaviors that often occur during traditional lecture-style practical sessions.

Table 6: Alignment of Findings with Tomlinson's Framework (2014)

Key Findings	Tomlinson Element (2014)	Supporting Literature
Apparatus competency & precise inferences	Process & Content Differentiation (Readiness & Profiles)	Osman et al. (2021); Bulunuz et al. (2016)
Active learning & inquiry motivation	Respectful Tasks & Flexible Learning Environment	Morgan (2014); Bondie et al. (2019)

CONCLUSION & IMPLICATIONS

8.1 Summary of Main Findings

Overall, implementing Tomlinson's (2014) differentiated Learning Stations helped Year 5 pupils develop better physical control of science equipment and build logically sound inferences based on practical evidence. The station rotation format minimized off-task behavior and encouraged pupils to take greater ownership of their practical work.

These findings carry several practical implications:

For Classroom Practice: The results demonstrate that primary science teachers can move away from one-size-fits-all practical sessions without overwhelming lab management. Using targeted scaffolding and station rotation allows teachers to act as facilitators who provide support where it is needed most.

For Teacher Education and Policy: Curriculum developers and teacher training institutions (such as IPG) can use these empirical insights to refine pedagogical guidelines for KSSR Science, incorporating hands-on station management into professional development modules.

Theoretical, Pedagogical & Policy Implications

- **Theoretical & Methodological:** Validates the applicability of Tomlinson's framework within psychomotor practical science domains in Malaysian primary schools and provides a robust qualitative triangulation
- matrix.

. **Teacher Pedagogical Practice:** Encourages a transition from *one-size-fits-all* teaching to responsive pedagogy.

Flexible station management enables teachers to act as facilitators delivering targeted scaffolding.

Policy Makers (MOE/JPN/IPG): Highlights the need to integrate practical Differentiated Learning Station design into Continuous Professional Development (CPD) for science teachers and upgrade primary school laboratory infrastructure.

RECOMMENDATIONS

Recommendations for Future Research

1. **Expanding Methodological Scale:** Apply quantitative or mixed-methods designs (e.g., quasi-experimental) with larger sample sizes across diverse school types (SJKC/SJKT/Rural) to test statistical generalizability.

2. **Digital & AI Integration:** Develop Digital Differentiated Learning Stations incorporating Augmented Reality (AR), PhET Interactive Simulations, and AI-driven adaptive learning platforms.

3. **Longitudinal Studies:** Measure the long-term retention of SPS mastery and motivation across extended academic periods.

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Main Appendices

Appendix A: Structured Observation Form (SPS & Student Engagement)

No	SPS & Student Engagement Indicators	Rating Scale (1-3) / Yes-No	Observation Field Notes
1	**Apparatus Handling:** Holding, selecting, and reading measuring apparatus (e.g., measuring cylinder) correctly and safely.	1 = Full SupportNeeded 2 = Minimal Support Needed 3 = Independent	Monitored meniscus reading eye-level accuracy and lab safety discipline at Station 2.
2	**Logical Inference Construction:** Articulating reasonable causes based on empirical practical observations.	1 = Full SupportNeeded 2 = Minimal Support Needed 3 = Independent	Assessed cause-and-effect reasoning connecting variables to observations at Station 3.
3	**Active Engagement & Motivation:** Demonstrating focus, peer collaboration, and self-regulated movement across stations.	Yes / No	Tracked pupil behavioral patterns (on-task vs off-task) during station rotations.

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Appendix B: School Administrative Approval Declaration

Sekolah Kebangsaan Durian Tunggal, Malacca

Ref. No: SKDT 001(1) | Date: 15.10.2026

Official Approval Letter to Conduct Thesis Data Collection granted to Researcher: Sangeeta a/p Perumal (UKM Matric No: P158376) entitled: "Implementation of the Learning Station Technique Based on Tomlinson's Differentiated Instruction Framework to Enhance Year 5 Pupils' Science Experimentation Skills".

Approved and endorsed by: **Siti Selyna binti Md Nasir (Headmistress, SK Durian Tunggal, Malacca)**.