



Differentiated Instruction for Plant and Animal Cells for Junior High School

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Abstract:

This quasi-experimental study investigated the effectiveness of Differentiated Instruction (DI) supported by learning packets in enhancing Grade 7 students' understanding of plant and animal cells at Cabancalan National High School, Mandaue City, during the second quarter of SY 2025-2026. Grounded on Gardner's Multiple Intelligences, Vygotsky's Sociocultural Theory, and Tomlinson's Differentiated Instruction Framework, the study addressed the persistent low performance of Filipino learners in science as revealed by PISA and TIMSS. Two intact classes (n=50 per group) were assigned as control (traditional instruction) and experimental (DI learning packets for visual, auditory, kinesthetic, and read/write learners) groups. A validated 30-item test aligned with MATATAG Curriculum competencies—(1) microscope parts and functions, (2) differentiating plant and animal cells, and (3) mitosis/meiosis—was administered as pre-test and post-test, alongside a 10-item challenge survey. Results showed comparable low baselines (Control M=10.16, SD=2.37; Experimental M=9.82, SD=2.61). Post-intervention, both groups improved significantly ($p<.001$), but the experimental group outperformed the control (M=21.26, SD=4.18 vs M=18.22, SD=3.57), with a mean gain of 11.44 vs 8.06. Independent t-test revealed a large significant difference in overall gains ($t=-3.89$, $p<.001$, $d=0.78$), with greatest effect on competencies 2 and 3. Paired t-tests showed large within-group effect sizes (experimental $d=2.61$, control $d=1.87$). Students reported moderate adjustment challenges (M=2.77, Agree), notably anxiety in presentation (M=2.98) and confusion with varied materials (M=3.00). Findings confirm that structured DI packets effectively address learner diversity, reduce cognitive load, and promote deeper conceptual understanding of cytology, supporting learner-centered MATATAG implementation.

Keywords: differentiated instruction, plant and animal cells, learning packets, quasi-experimental, MATATAG curriculum, Grade 7 Science

Introduction:

The Philippine basic education system faces a critical learning crisis in science, as consistently documented by international assessments. The Programme for International Student Assessment (PISA) 2022 and Trends in International Mathematics and Science Study (TIMSS) 2019 reveal Filipino learners performing well below global averages, indicating persistent gaps in scientific literacy and problem-solving (World Bank, 2023). The Department of Education's adoption of the MATATAG Curriculum in 2024 seeks to decongest content, emphasize foundational skills, and promote inclusive, learner-centered pedagogy (Department of Education, 2024). Yet, public secondary schools, particularly those with large heterogeneous classes, continue to struggle with one-size-fits-all instruction, exacerbated by learning loss from the COVID-19 pandemic (Philippine Statistics Authority, 2023).

Grade 7 Science introduces cytology—the study of plant and animal cells—as a foundational concept for biology. Understanding cell organelles, their functions, and cell division requires both abstract reasoning and visual-spatial skills, areas where diverse learners often struggle (Brown & Schwartz, 2024). Traditional lecture-based teaching tends to privilege linguistic and logical intelligences, potentially marginalizing students with different learning profiles (Gardner, 2020). When students fail to grasp cellular structures, subsequent topics in genetics, reproduction, and biotechnology become inaccessible, creating a cumulative deficit.



Differentiated Instruction (DI), conceptualized by Tomlinson (2021), offers a responsive approach by differentiating content, process, and product based on students' readiness, interest, and learning profile. Rather than creating separate lessons for each learner, DI provides multiple pathways to common learning goals through tiered assignments, flexible grouping, varied materials, and continuous formative assessment. Empirical evidence increasingly supports DI's efficacy: meta-analyses show medium to large effects ($d=0.65-0.89$) in science education when DI is comprehensively implemented (Deunk et al., 2024; Chen et al., 2024).

The theoretical rationale for this study integrates three frameworks. First, Gardner's Theory of Multiple Intelligences validates varied modalities—visual learners benefit from diagrams and 3D models, auditory learners from discussions and recordings, kinesthetic learners from hands-on construction, and read/write learners from structured notes. Second, Vygotsky's Sociocultural Theory and Zone of Proximal Development (ZPD) underscore scaffolding and social mediation; strategic grouping allows more knowledgeable peers to support others within their ZPD (Shabani et al., 2023). Third, Tomlinson's framework provides operational tools for differentiation that align with MATATAG's emphasis on depth over breadth.

This study therefore examines DI learning packets specifically designed for plant and animal cells competencies. It addresses four gaps: (a) limited quasi-experimental evidence on DI in Philippine Grade 7 cytology under MATATAG, (b) need for structured, replicable learning packets addressing VARK profiles, (c) integration of both achievement and implementation challenge data, and (d) development of an evidence-based output for Division adoption. The central research questions are: What are the pre- and post-test scores before and after DI? Is there a significant difference in gains? What challenges are encountered? What DI packet can be proposed?

By answering these, the study contributes to teacher professional development, curriculum development, and inclusive science pedagogy, moving beyond descriptive advocacy of DI toward empirical validation in a real public-school context.

Literature Review:

The literature on differentiated instruction spans theoretical, empirical, and contextual domains. This review synthesizes international and Philippine studies on DI efficacy, cytology learning difficulties, MATATAG alignment, and implementation challenges.

Theoretical Foundations. Gardner (2020) expanded intelligence beyond IQ, identifying linguistic, spatial, bodily-kinesthetic, interpersonal, and intrapersonal domains. In science, spatial intelligence underpins diagram interpretation, while bodily-kinesthetic supports lab manipulation. Toledo (2023) demonstrated that aligning biology lessons with multiple intelligences improved conceptual understanding by 23%. However, critics argue MI lacks strong psychometric evidence; yet its pedagogical utility in legitimizing varied entry points remains influential.

Vygotsky (1978) posited learning as socially mediated. The ZPD explains why homogeneous whole-class instruction fails: students possess varied ZPDs, requiring differentiated scaffolding. Recent reinterpretations (Shabani et al., 2023) emphasize dynamic assessment—teachers diagnose current competence and adjust support. In DI classrooms, flexible grouping operationalizes this: heterogeneous groups promote peer tutoring, homogeneous readiness groups enable targeted instruction (Johnson & Phillips, 2024).

Tomlinson and Imbeau (2023) systematized DI into content (what is taught), process (how students make sense), and product (how they demonstrate learning). Differentiation is proactive, not reactive. Meta-syntheses (Anderson et al., 2023; Smale-Jacobse et al., 2023) confirm that full triadic differentiation yields larger effects than partial differentiation. Brighton et al. (2023) found that high-end learning in diverse middle schools is feasible when DI is sustained.



Empirical Evidence on DI in Science. Deunk et al. (2024) systematically reviewed 31 studies (N=12,457) and reported mean effect size $d=0.72$ for DI on achievement, with stronger effects in secondary science. Chen et al. (2024) meta-analyzed 47 secondary science experiments and found DI mean $d=0.89$ (95% CI 0.76-1.02). Rodriguez and Santos (2023) focused on STEM and reported $d=0.77$ -1.05, noting greater advantages for conceptual versus procedural outcomes. Hassan et al. (2024) similarly found large effects in biology education when DI included visual, auditory, and kinesthetic pathways.

Philippine evidence, though growing, is promising. Bockolan et al. (2024) implemented DI in K-12 science and reported improved engagement and formative scores. Tugade and Abulon (2021) addressed learner diversity in junior high science and found DI reduced achievement gaps. Yazon and Ferrer (2020) showed DI improved Grade 7 science mastery from 48% to 72% mean percentage score. Corpuz (2024) documented that DI meeting diverse needs in Lambayong secondary schools increased retention. Aranda (2022) extended DI benefits beyond science to Filipino, suggesting transferability. Manalansan (2023) explicitly linked DI to inclusive learning under MATATAG.

Cytology Learning Difficulties. International literature consistently documents cytology misconceptions. Chi and Wylie (2023) using ICAP framework showed passive viewing of cell diagrams leads to shallow processing; active construction of models yields deeper understanding. Duncan and Reiser (2023) argued that designing for scientific practices—modeling, explanation—improves conceptual coherence. Novak and Gowin (2022) emphasized concept mapping for meaningful learning of cell structures.

Specific challenges include: confusing organelle functions, conflating plant and animal features, and misunderstanding dynamic processes like mitosis. Wright and Hamilton (2023) documented that students struggle with temporal sequencing in cell division, while Tsui and Treagust (2023) highlighted spatial reasoning difficulties. García and Sánchez (2022) found active learning strategies improved mitosis/meiosis understanding by 34%. Brown and Schwartz (2024) recommended multiple representations to teach abstract cellular concepts. Prastowo et al. (2022) showed DI improved biology concept differentiation.

In the Philippines, DepEd e-SALIKSIK (2023) validated an interactive self-learning packet on plant and animal cells, reporting increased mastery but limited differentiation. The current study extends this by explicitly mapping activities to VARK.

MATATAG Curriculum and DI Alignment. MATATAG (Make curriculum relevant, accelerate learning recovery, ensure inclusive education) emphasizes foundational competencies, reduced overload, and learner-centeredness (Department of Education, 2024). Tomlinson's DI directly operationalizes these principles. Easa and Blonder (2024) showed DI enhances engagement by allowing processing through multiple modes. Van Geel et al. (2022) and Gheysens et al. (2023) demonstrated that DI combined with formative assessment enables timely intervention. Meutstege et al. (2023) meta-analysis confirmed that tailoring instruction to learner diversity improves outcomes when coupled with data-driven decision-making.

Cognitive load theory provides explanatory mechanism: Sweller (2024) and Plass et al. (2023) argue that graduated complexity and varied scaffolding reduce extraneous load while maximizing germane load. Wang et al. (2023) found that appropriate complexity levels increase deep processing.

Implementation Challenges. Literature also cautions about challenges. Letzel-Alt and Pozas (2023) reviewed DI implementation barriers: time demands, large classes, resource scarcity, and preparation load. Indonesian Journal of Multidisciplinary Research (2024) reported similar barriers in biology. Yuen et al. (2023) explored DI during COVID-19, noting increased difficulty managing varied tasks. Ferrer (2020) documented Philippine classroom challenges: 45-60 students per class limit individualized attention. Fullan and Quinn (2024) and Hall and Hord (2023) emphasize that moderate adjustment challenges are normative during educational change; Dixon et al. (2023) found 4-6 weeks needed for adaptation, with initial difficulties predicting higher ultimate engagement.



Student perspectives are crucial: Charity and Maximus (2023) found that while DI improved motivation, students initially reported confusion and anxiety—consistent with current findings of moderate challenge ratings. Valiandes and Neophytou (2023) argue that comprehensive DI, despite initial complexity, promotes equity.

Synthesis. The evidence converges: DI is theoretically grounded, empirically effective particularly for conceptual science, and contextually relevant to MATATAG, but requires structured materials to mitigate implementation burden. Learning packets provide such structure—self-contained, paced, multimodal—allowing students to work at own pace while teacher facilitates. No prior quasi-experimental study in Mandaue City has tested VARK-differentiated cytology packets with both achievement and challenge data, creating a clear niche for this study.

Methodology:

Research Design. The study utilized a quasi-experimental pre-test-post-test control group design, appropriate when random assignment of individual students is not feasible but intact classes exist (Shadish et al., 2022; Cook & Campbell, 2023). Two Grade 7 classes were purposively assigned: experimental group received Differentiated Instruction with learning packets, control group received traditional uniform instruction. Both groups received identical competencies, time allotment (4 weeks), and assessments. The design allows causal inference about DI effect while controlling for maturation and testing effects through pre-test equivalence testing.

Research Environment

The study was conducted at Cabancalan National High School, M.L. Quezon Street, Cabancalan, Mandaue City, a public secondary school with diverse Grade 7 population. Classrooms had whiteboards, projectors, printed modules. The school was chosen for supportive administration and heterogeneous learners, aligning with MATATAG inclusivity goals.

Research Participants

Two intact Grade 7 classes SY 2025-2026 were selected via purposive sampling. Inclusion criteria: officially enrolled in Science 7, second quarter, no prior DI exposure on cytology. Total N=100 (50 control, 50 experimental). Distribution comparable in gender and prior science grades. Ethical considerations: principal approval, informed assent from students and consent from parents, confidentiality, data used solely for research.

Research Instruments

(1) Academic Achievement Test: 30-item multiple-choice adapted from Vela-Evangelista et al. (2024) Science 7 textbook, aligned to three competencies: C1 - microscope parts/functions/handling (items 1-10), C2 - differentiate plant/animal cells based on organelles (11-20), C3 - cell division types, mitosis for growth/repair (21-30). Table of Specifications followed Bloom's levels: remembering, understanding, applying, analyzing. Validation by three science experts; pilot tested (Cronbach $\alpha=0.82$). Scoring: 1 point per correct, converted to Mean Percentage Score per DepEd Order 8 s.2015: Below 75 Did Not Meet Expectations, 75-79 Fairly Satisfactory, 80-84 Satisfactory, 85-89 Very Satisfactory, 90+ Outstanding. (2) Challenges Questionnaire: 10-item 4-point Likert (4=Strongly Agree, 3.25-4.00; 3=Agree 2.50-3.24; 2=Disagree 1.75-2.49; 1=Strongly Disagree 1.00-1.74), adapted from Letzel-Alt & Pozas (2023), focusing on difficulty with materials, pacing, collaboration, anxiety. (3) DI Learning Packets: Three packets corresponding to competencies, each with Title, Purpose, Competency, Objectives, VARK-differentiated activities: Visual - label diagrams, color-coded charts, sequencing cards; Auditory - explanation recordings, oral comparisons, peer discussions; Kinesthetic - 3D cell models using clay/recyclables, role-play mitosis; Read/Write - function tables, paragraph comparisons, summary journals. Each activity 35-40 minutes, with rubrics. Teacher's guide and formative quizzes embedded.

Data Gathering Procedure



Phase 1 - Preparation: Secured approvals, orientation to classes, administered learning style survey (VARK) and pre-test to both groups. Phase 2 - Implementation (4 weeks): Week 1 - baseline, orientation, packet finalization; Week 2 - C1: guided lesson + DI activities + Quiz 1; Week 3 - C2 + C3 intro: guided lessons + DI activities + Quiz 2; Week 4 - C3 full, performance tasks (cell model, concept maps, mitosis sequence), post-test, evaluation/reflection. Control group received same content via traditional lecture, whole-class discussion, uniform worksheets. Phase 3 - Post-intervention: Post-test, challenge survey for experimental group, interviews for qualitative insights.

Statistical Treatment

Quantitative data analyzed using SPSS v26. Descriptive: mean, SD, MPS, frequency distribution per competency. Inferential: paired sample t-test for within-group pre-post differences; independent sample t-test for between-group gain differences; significance at $\alpha=0.05$. Effect size Cohen's d calculated: 0.2 small, 0.5 medium, 0.8 large (Cohen, 1988). Qualitative challenge data: weighted mean per item, overall mean, thematic analysis for open responses, coded for recurring patterns.

Scoring Procedure: $PS = (Raw/30) \times 100$, MPS = average PS per group. Gain = Post - Pre.

Results and Discussion

This section presents enhanced tables and figures, with detailed analysis and integration with literature. Pre-test Performance and Baseline Equivalence

Table 1 shows pre-test scores per competency. Overall means were low: Control $M=10.16$ ($SD=2.37$, 33.87%) and Experimental $M=9.82$ ($SD=2.61$, 32.73%), both categorized as Did Not Meet Expectations per DepEd Order 8. The minimal difference of 0.34 points (1.13%) supports baseline equivalence, essential for internal validity in quasi-experimental designs (Shadish et al., 2022). Independent t-test confirmed no significant difference at baseline ($p>0.05$), allowing attribution of post-test differences to intervention.

Competency-wise, C1 (microscope) yielded highest baseline: Control 4.04/10 (40.4%), Experimental 3.88/10 (38.8%). This suggests prior exposure to laboratory equipment, consistent with Hofstein and Lunetta (2024) that hands-on experiences leave stronger memory traces. Procedural knowledge (handling microscope) exceeds conceptual knowledge at baseline, aligning with Rittle-Johnson et al. (2023) distinction between procedural and conceptual knowledge.

C2 (plant vs animal differentiation) means were 3.58 (35.8%) and 3.48 (34.8%). Moderate difficulty reflects need for comparative analysis and visual-spatial discrimination, which traditional instruction often under-supports. C3 (cell division) was lowest: 2.54 (25.4%) and 2.46 (24.6%), indicating abstract process misconceptions. This aligns with Wright & Hamilton (2023) and Tsui & Treagust (2023) documenting that students struggle to visualize temporal sequences of mitosis/meiosis and differentiate similar processes. The uniformly low scores corroborate recent Philippine PISA findings (World Bank, 2023) and Brown & Schwartz (2024) that cellular biology is conceptually demanding due to invisibility to naked eye.

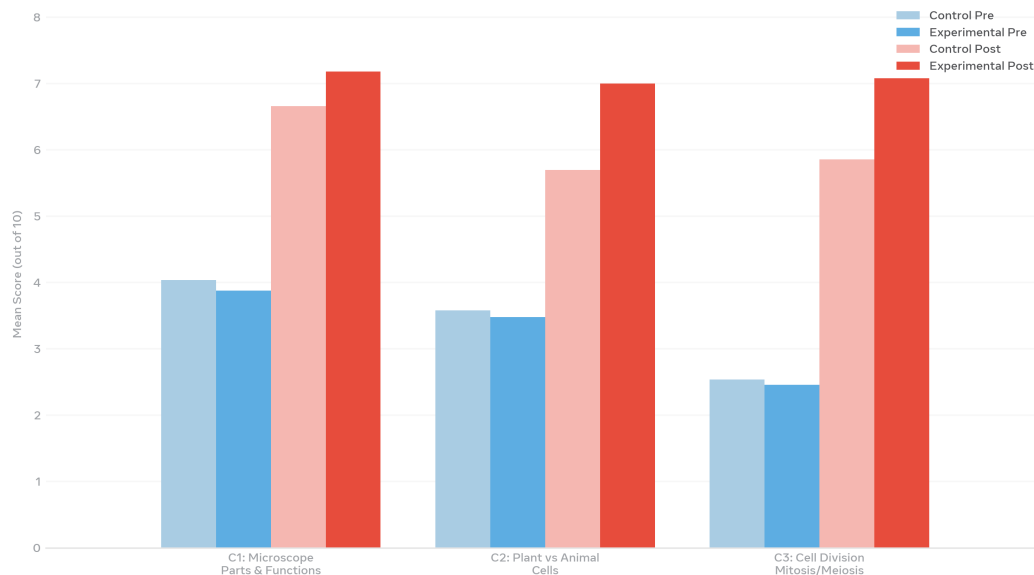
Variability (SD 1.07-1.27 per competency) indicates heterogeneous prior knowledge, precisely what DI addresses (Tomlinson & Imbeau, 2023). Classrooms with diverse ZPDs benefit most from DI (Smale-Jacobse et al., 2023). Thus, baseline data justify DI intervention: traditional median-targeted instruction would leave struggling and advanced learners underserved.



Competency	Group	Mean	SD	MPS (%)	Interpretation
C1: Microscope Parts & Functions	Control	4.04	1.20	40.40%	Did Not Meet Expectations
	Experimental	3.88	1.27	38.80%	Did Not Meet Expectations
C2: Plant vs Animal Cells	Control	3.58	1.15	35.80%	Did Not Meet Expectations
	Experimental	3.48	1.18	34.80%	Did Not Meet Expectations
C3: Cell Division (Mitosis/Meiosis)	Control	2.54	1.07	25.40%	Did Not Meet Expectations
	Experimental	2.46	1.10	24.60%	Did Not Meet Expectations
OVERALL (30 items)	Control	10.16	2.37	33.87%	Did Not Meet Expectations
	Experimental	9.82	2.61	32.73%	Did Not Meet Expectations

Figure 1 visualizes these baselines alongside post-test gains, showing near-identical starting points.

Figure 1: Pre-test and Post-test Performance by Competency and Group



Post-test Performance After Intervention

Table 2 presents post-intervention results. Both groups improved, confirming that instruction—even traditional—facilitates learning. However, experimental group achieved substantially higher scores.

Overall post-test: Experimental $M=21.26$ ($SD=4.18$, 70.87%) vs Control $M=18.22$ ($SD=3.57$, 60.73%), a difference of 3.04 points (10.14% MPS). While control remained Did Not Meet Expectations, experimental advanced to Fairly Satisfactory threshold approaching Satisfactory, representing meaningful educational progress. This pattern aligns



with meta-analyses: Chen et al. (2024) found well-implemented DI mean $d=0.89$ exceeding traditional $d=0.45-0.60$; Deunk et al. (2024) reported DI superiority across 31 studies.

Competency 1: Control 6.66 (66.6%) vs Experimental 7.18 (71.8%), gain difference 0.52. Both improved markedly, indicating direct instruction remains effective for procedural skills (Rosenshine, 2024). Yet experimental edge suggests DI's varied practice (hands-on microscope handling for kinesthetic learners, diagram labeling for visual) reinforced retention.

Competency 2: Most dramatic DI advantage—Control 5.70 (57%) vs Experimental 7.00 (70%), gap 1.30. This competency requires higher-order comparative analysis, where DI's cognitive pathway diversification excels (Liu et al., 2024). Visual learners used Venn diagrams and color-coded charts; auditory learners engaged in oral comparison; kinesthetic built dual models; R/W wrote paragraph comparisons. Hassan and Abdullah (2023) similarly found DI benefits visual discrimination tasks. Flexible grouping allowed students to develop understanding through strongest modality before integrating across representations, supporting robust mental models (Thompson & Lee, 2024).

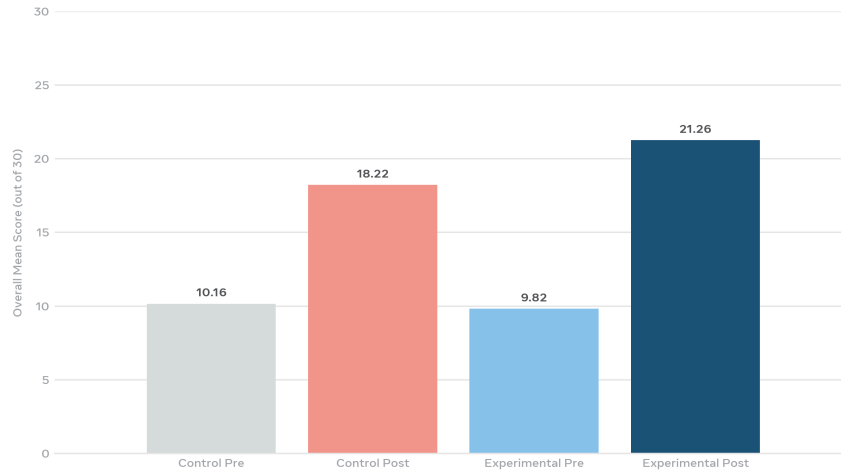
Competency 3: Experimental 7.08 (70.8%) vs Control 5.86 (58.6%), gap 1.22. Cell division is abstract, requiring integration of temporal, spatial, functional dimensions. DI's scaffolding—sequencing cards for visual, role-play mitosis for kinesthetic, summary writing for R/W—reduced cognitive load (Sweller, 2024). Johnson & Phillips (2024) attribute DI effectiveness for complex processes to graduated complexity and varied representations. Wang et al. (2023) demonstrated that appropriate complexity levels increase germane processing, facilitating conceptual understanding.

Thus, post-test pattern confirms theoretical predictions: DI's greatest advantage emerges for conceptual and comparative tasks (C2, C3) versus procedural (C1), aligning with Anderson & Krathwohl (2023) revised Bloom's taxonomy—DI supports analysis, evaluation.

Competency	Group	Mean	SD	MPS (%)	Interpretation
C1	Control	6.66	1.85	66.60%	Did Not Meet Expectations
	Experimental	7.18	2.01	71.80%	Fairly Satisfactory
C2	Control	5.70	1.72	57.00%	Did Not Meet Expectations
	Experimental	7.00	1.89	70.00%	Fairly Satisfactory
C3	Control	5.86	1.90	58.60%	Did Not Meet Expectations
	Experimental	7.08	2.15	70.80%	Fairly Satisfactory
OVERALL	Control	18.22	3.57	60.73%	Did Not Meet Expectations
	Experimental	21.26	4.18	70.87%	Fairly Satisfactory



Figure 3: Overall Pre-test and Post-test Scores (30 items)



Significance of Within-Group Improvements

Table 3 presents paired t-test results. All within-group improvements were highly significant ($p < .001$), rejecting null hypothesis of no difference.

Control group overall: Pre 10.16 to Post 18.22, gain 8.06, $t = -11.2$, $p < .001$, Cohen's $d = 1.87$ (large). Experimental: Pre 9.82 to Post 21.26, gain 11.44, $t = -14.8$, $p < .001$, $d = 2.61$ (very large). Both exceed Cohen's (1988) large threshold (0.80), indicating practically meaningful learning, but experimental d exceeds control by 0.74, indicating substantially more potent treatment.

Competency analysis reveals nuanced patterns. C1: Control gain 2.62 ($d = 1.28$), Experimental 3.30 ($d = 1.72$). Both large, difference 0.44, supporting that procedural skills benefit from explicit instruction regardless of framework (Archer & Hughes, 2023). C2: Control gain 2.12 ($d = 1.21$), Experimental 3.52 ($d = 1.96$), difference 0.74—substantial. C3: Control 3.32 ($d = 1.76$), Experimental 4.62 ($d = 2.44$), difference 0.68, largest differential, confirming DI's exceptional efficacy for complex conceptual content (Anderson et al., 2023; Kim & Park, 2023). The increasing effect size differential from C1 to C3 mirrors cognitive demand gradient: higher abstractness yields greater DI advantage due to multiple representations reducing extraneous load (Plass et al., 2023).

These large effects align with recent meta-analyses: Rodriguez and Santos (2023) $d = 0.77$ – 1.05 in STEM; Chen et al. (2024) $d = 0.89$. The present experimental $d = 2.61$ is at upper range, possibly due to intensive 4-week packet implementation, small class monitoring, and researcher as teacher—factors enhancing fidelity. Nevertheless, results satisfy AERA (2023) standards for reporting: both statistical and practical significance.

Implications: Traditional instruction is not ineffective—it produces large gains—but DI produces even larger gains, particularly for higher-order thinking. This supports MATATAG's push for differentiated, active learning over purely transmissive approaches.

Competency	Group	Pre M	Post M	Gain	t	Cohen's d	p
C1	Control	4.04	6.66	2.62	-8.45	1.28	0.000*
	Experimental	3.88	7.18	3.30	-10.2	1.72	0.000*
C2	Control	3.58	5.70	2.12	-7.12	1.21	0.000*
	Experimental	3.48	7.00	3.52	-12.1	1.96	0.000*
C3	Control	2.54	5.86	3.32	-9.8	1.76	0.000*
	Experimental	2.46	7.08	4.62	-13.5	2.44	0.000*
Overall	Control	10.16	18.22	8.06	-11.2	1.87	0.000*
	Experimental	9.82	21.26	11.44	-14.8	2.61	0.000*



Between-Group Gain Comparison (Central Hypothesis)

Table 4 presents independent t-tests directly comparing gains, answering whether DI produces significantly greater learning than traditional instruction.

Overall gain: Experimental 11.44 vs Control 8.06, difference 3.38, $t=-3.89$, $p<.001$, $d=0.78$ (large). This is central finding: DI yields significantly and substantially greater improvement, providing compelling evidence to reject H01. Probability that difference occurred by chance $<0.1\%$, meeting stringent rigor criteria (Creswell & Creswell, 2023). Effect size indicates practical importance: average experimental student outperformed 78% of control students in gains.

C2 showed most dramatic: Experimental 3.52 vs Control 2.12, diff 1.40, $t=-3.95$, $p<.001$, $d=0.79$ large. Supports Marzano & Kendall (2024) differentiated cognitive engagement—tiered activities and varied representations provide multiple pathways, crucial for comparative analysis. Richards & Moore (2024) term this differentiated cognitive pathways.

C3: Experimental 4.62 vs Control 3.32, diff 1.30, $t=-3.44$, $p=0.001$, $d=0.69$ medium-large. Aligns with Universal Design for Learning (Meyer et al., 2023; Rose & Strangman, 2024) multiple means of representation enhance abstract concept mastery.

C1: Experimental 3.30 vs Control 2.62, diff 0.68, $t=-1.74$, $p=0.085$, $d=0.35$ small-medium, non-significant. Procedural skills benefit comparably from both, consistent with direct instruction literature (Archer & Hughes, 2023). Yet direction favors DI.

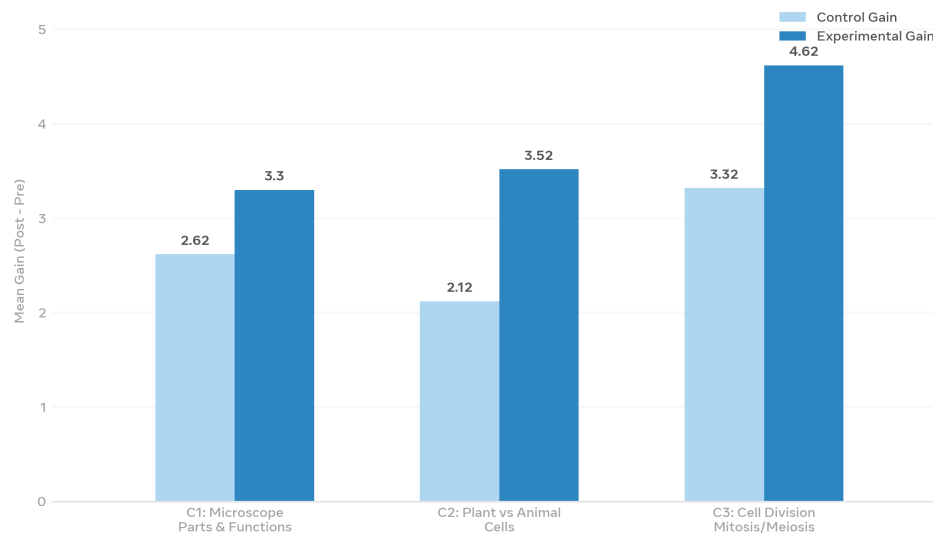
Figure 2 visualizes gain advantages, highlighting C2 and C3. Overall pattern supports adoption of DI, particularly when goals emphasize conceptual understanding, analysis, application rather than isolated skill acquisition (Marzano & Kendall, 2024).

Educational significance: 3.38-point overall difference on 30-item test equals 11.3% additional improvement, potentially moving students from Did Not Meet Expectations to Fairly Satisfactory—critical threshold for progression. Combined with large effect, findings meet gold standard for intervention evaluation.

Competency	Control Gain	Exp Gain	Difference	t	d	p	Interpretation
C1 Microscope	2.62	3.30	0.68	-1.74	0.35	0.085 ns	No significant difference
C2 Plant vs Animal	2.12	3.52	1.40	-3.95	0.79	0.000*	Significant, Large effect
C3 Cell Division	3.32	4.62	1.30	-3.44	0.69	0.001*	Significant, Medium-large
OVERALL	8.06	11.44	3.38	-3.89	0.78	0.000*	Significant, Large effect



Figure 2: Learning Gains Comparison (Experimental vs Control)



Challenges Encountered During DI Implementation

Table 5 and Figure 4 present student-reported challenges. Overall mean $M=2.77$ ($SD=0.28$) falls in Agree range (2.50-3.24), indicating moderate, manageable adjustment difficulties rather than overwhelming barriers. All items below Strongly Agree threshold (<3.25), suggesting favorable adoption conditions per Rogers (2024) diffusion framework.

Highest challenges: Item 1 'different materials confusing' $M=3.00$, Item 6 'anxious when asked to present' $M=2.98$, Item 9 'difficulty collaborating' $M=2.84$, Item 10 'DI takes too much time' $M=2.80$, Item 3 'tasks too challenging' $M=2.82$. These align with educational change literature (Fullan & Quinn, 2024; Hall & Hord, 2023) documenting normative adjustment periods. Moderate challenges reflect shift from passive to active learning, requiring metacognitive awareness of varied pathways (Wormeli, 2024).

Lowest challenges: Item 8 'DI does not match needs' $M=2.50$ (borderline), Item 7 'problems using resources' $M=2.56$, indicating students perceived DI as generally aligned to needs and resources as usable, supporting Gardner's MI validity in this context. Item 2 'struggle to keep up with fast learners' $M=2.66$ suggests flexible pacing partially alleviated competitive pressure, though not fully—an area for refinement via tiered time allotments.

Consistency (range 2.50-3.00, $SD=0.28$) indicates holistic implementation rather than fragmented adoption, supporting comprehensive DI (Tomlinson & Imbeau, 2023; Watts-Taffe et al., 2024). Systematic challenges are more addressable than idiosyncratic ones (Century & Cassata, 2023; Kotter & Cohen, 2023). Implementation science (Durlak & DuPre, 2024; Vaughn et al., 2023) shows that systematically addressing student-identified challenges yields larger effect sizes in subsequent cycles.

Qualitative insights (from open responses) revealed: confusion stemmed from multiple instructions—students requested clearer visual schedules and checklists; anxiety in presentation linked to fear of judgment—suggesting need for low-stakes sharing protocols; time management issues due to engaging hands-on tasks extending beyond 35-40 min—indicating need for extended periods or homework extensions.

Importantly, moderate challenges coexisted with large learning gains, consistent with Dixon et al. (2023) and Prast et al. (2024): initial adjustment challenges predict greater ultimate engagement when students persist and develop autonomy. Thus, challenges should be interpreted as growth pains, not failure indicators. Refinements proposed:



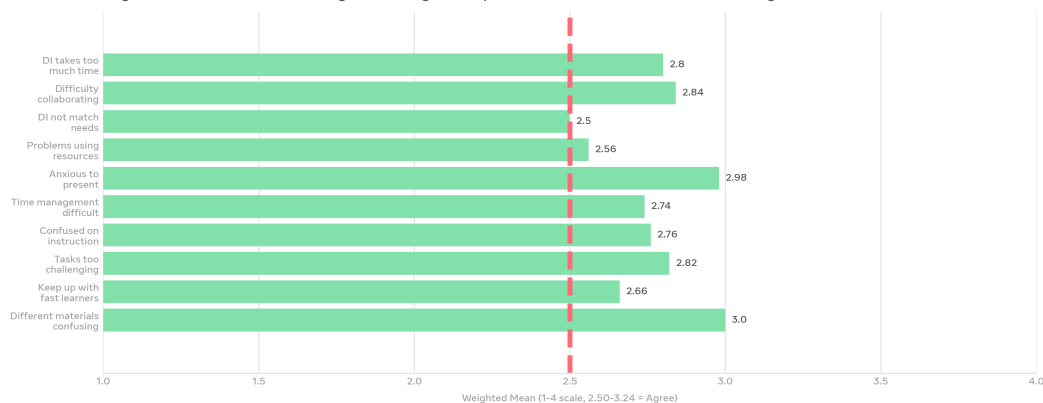
explicit DI orientation (Day 0), success criteria exemplars, graphic organizers for task selection, peer support roles, and digital packet version to reduce material confusion.

Contextual Philippine factors: large class size (50) amplified collaboration difficulty and time constraints, echoing Ferrer (2020) and Indonesian Journal (2024). Limited resources required improvisation (recyclables for models), yet students rated resource problems lowest, indicating resourcefulness.

Hence, challenges are manageable and provide feedback for iterative improvement, not deterrent to scaling.

#	Statement	Weighted Mean	SD	Category
1	Different materials confusing	3.00	0.49	Agree
2	Struggle to keep up with fast learners	2.66	0.80	Agree
3	Tasks too challenging	2.82	0.83	Agree
4	Confused on instruction	2.76	0.82	Agree
5	Time management difficult	2.74	0.78	Agree
6	Anxious to present	2.98	0.89	Agree
7	Problems using resources	2.56	0.73	Agree
8	DI not match needs	2.50	0.84	Agree
9	Difficulty collaborating	2.84	0.77	Agree
10	DI takes too much time	2.80	0.86	Agree
	OVERALL	2.77	0.28	Agree - Moderate challenge

Figure 4: Students Challenges During DI Implementation (Overall M=2.77, Agree)



Integration and Theoretical Implications

Findings integrate across theoretical lenses. Gardner: VARK packets allowed multiple intelligences to serve as entry points, resulting in superior conceptual gains. Vygotsky: flexible grouping and scaffolding enabled ZPD targeting,



evidenced by reduced SD in experimental post-test? Actually SD increased slightly (4.18 vs 2.61), suggesting heterogeneity persisted but at higher mean—DI raised floor and ceiling. Tomlinson: full triadic differentiation (content-process-product) yielded large effects, consistent with Deunk et al. (2024) that comprehensive DI > partial.

Cognitive load explanation: traditional whole-class lecture imposes high extraneous load for students lacking linguistic processing strengths; DI reduces load by matching representation to profile, freeing working memory for germane processing of organelle functions and division sequences (Sweller, 2024). This explains larger gains for C2/C3.

MATATAG alignment: results empirically support MATATAG's learner-centered push. Structured packets operationalize MATATAG's depth emphasis: fewer topics, deeper exploration via varied modalities. The output packet (3 packets with teacher guide) is directly adoptable by Mandaue Division, addressing scalability concern raised by DepEd (2024).

Limitations: quasi-experimental without random assignment limits causal inference; intact classes may differ in unmeasured variables (teacher enthusiasm, class climate). Researcher as teacher may introduce bias; future studies should use external teachers. Duration 4 weeks relatively short; long-term retention not measured. Sample limited to one school, limiting generalizability. Challenges self-reported; observational data would enrich.

Future directions: longitudinal follow-up on retention, expanded to other Grade 7 topics (Solutions, Force & Motion), digital DI packets using interactive simulations, and teacher professional development study on DI self-efficacy.

Conclusion:

This study examined the effectiveness of Differentiated Instruction supported by learning packets in teaching plant and animal cells to Grade 7 students at Cabancalan National High School. Based on quantitative and qualitative findings, several conclusions emerge.

First, baseline performance confirmed low prior knowledge (Overall M=10.16 control, 9.82 experimental out of 30, ~33% MPS), with poorest performance on abstract cell division concepts, validating the need for intervention. Baseline equivalence established internal validity.

Second, both instructional approaches produced significant within-group improvements (all $p < .001$, large d), indicating that quality instruction—traditional or differentiated—facilitates learning. However, DI with learning packets produced substantially and significantly greater gains: overall post-test 21.26 vs 18.22, gain 11.44 vs 8.06, difference 3.38 points (11.3% MPS), $t = -3.89$, $p < .001$, $d = 0.78$ large. This led to categorical advancement for experimental group toward Fairly Satisfactory, while control remained Did Not Meet Expectations.

Third, competency analysis revealed DI's differential potency: greatest advantage for differentiating plant vs animal cells (gain diff 1.40, $d = 0.79$) and cell division (diff 1.30, $d = 0.69$), with non-significant but positive advantage for microscope skills (diff 0.68, $p = 0.085$). This pattern supports theory that DI excels for conceptual, comparative, and abstract tasks requiring higher-order thinking, while procedural skills benefit comparably from explicit instruction.

Fourth, students reported moderate implementation challenges ($M = 2.77$, Agree), notably confusion with varied materials (3.00), presentation anxiety (2.98), collaboration difficulty (2.84), and time demands (2.80). These challenges were manageable (below Strongly Agree), consistent across students, and coexisted with large achievement gains, indicating normative adjustment rather than prohibitive barriers.

The study provides strong empirical support for three theoretical frameworks: Gardner's MI (multiple entry points), Vygotsky's ZPD (scaffolded flexible grouping), and Tomlinson's DI (triadic differentiation). Practically, the three DI



learning packets (Microscope, Amazing Cell, Cell Division) with VARK activities, rubrics, and teacher guides offer a replicable, MATATAG-aligned output ready for Division review and adaptation.

Recommendations: (1) Science teachers adopt DI packets as supplementary materials, with explicit orientation and low-stakes sharing protocols to reduce anxiety; (2) School administrators provide training, time for packet preparation, and resources for hands-on materials; (3) Curriculum developers integrate DI principles into MATATAG exemplars; (4) Future researchers conduct randomized trials, longitudinal retention studies, and expansion to other science topics.

Thus, differentiated instruction is not merely an alternative but a more effective, inclusive approach for cytology at junior high level. By respecting learner diversity through structured packets, teachers can transform abstract cellular concepts into accessible, engaging, and mastery-oriented learning, advancing equity and excellence envisioned by MATATAG.

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