

Scaffolding Articulation: Fostering Deeper Understanding of Genetic Mutation in Grade 10 Biology

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Abstract. Genetic mutation is a foundational yet complex topic in Grade 10 biology, often posing challenges for learners to articulate clearly due to unfamiliar terminology and abstract processes. This action research was conducted in a public secondary school biology class, utilizing a scaffolded teaching approach to develop learners' articulation ability in the context of genetic mutation. Strategies included scaffolded questioning, structured peer teaching, and learner progress checklists. The data sources included daily written evaluations, classroom observations, and recorded learner discussions. Results indicated only modest improvements in learners' written assessments, with mean class-level proficiency scores of 74% on the first day, 76% on the second day, and 79% on the third day, suggesting a limited impact on formal testing outcomes. However, the qualitative findings told a richer story: learners demonstrated growing confidence in explaining genetic mutations, an increasing use of scientific vocabulary, and greater participation in collaborative discussions. Thematic analysis revealed progress in organizing ideas and articulating complex biological concepts during class activities. These findings suggest that scaffolding is most effective as a tool for fostering conceptual articulation, rather than a strategy for formal test preparation. The study underscores that for action researchers and practitioners, capturing the evolving voice of learners through qualitative methods is crucial for understanding the actual impact of an intervention.

Keywords: Action research; Articulation; Genetic mutation; Peer teaching; Scaffolding

1.0 Introduction

Genetic mutation, a key subtopic within genetics, provides students with a gateway into understanding how alterations in DNA sequences can result in a range of physiological outcomes, including genetic disorders such as hemophilia, a condition caused by a mutation that impairs blood clotting (CDC, 2022). Despite the scientific intrigue and real-world relevance of this topic, it remains conceptually difficult for many learners due to its abstract nature and the specialized terminology it involves (Smith & Knight, 2012; Mussard & Reiss, 2022). These challenges are particularly pronounced in high school settings, where students are still developing their capacity for abstract reasoning and scientific communication.

Recent educational disruptions due to the COVID-19 pandemic have exacerbated these difficulties. Dela Cruz and colleagues in their systematic review have shown that a year of school closure is associated with 1.1 years of learning loss (Dela Cruz et al., 2025). As face-to-face instruction resumes, educators have noted a decline in students' communicative abilities, classroom engagement, and willingness to participate in discussions (Anzaldo, 2021; Tagare, 2023). These shifts are particularly evident in science classrooms, where verbal expression of

complex ideas is often required. Post-pandemic learning loss, including decreased attention spans and reluctance to articulate understanding, presents a significant barrier to comprehension in concept-heavy topics such as genetic mutation (Pinuela, 2025).

A classroom-based problem analysis (Peracullo, 2022) conducted at a public high school in Baybay City, Leyte, highlighted that Grade 10 learners frequently struggled not only with understanding heredity content but also with articulating their thoughts about it. Students expressed difficulty in explaining scientific concepts, which was manifested in poor comprehension and low academic performance. Using a problem tree analysis, the central issue was identified as a lack of comprehension (Figure 1). There were two identified causes: difficulty understanding and the inability to articulate ideas in heredity. In this action research, we focused on improving the ability to articulate hereditary concepts (shown in green text boxes).

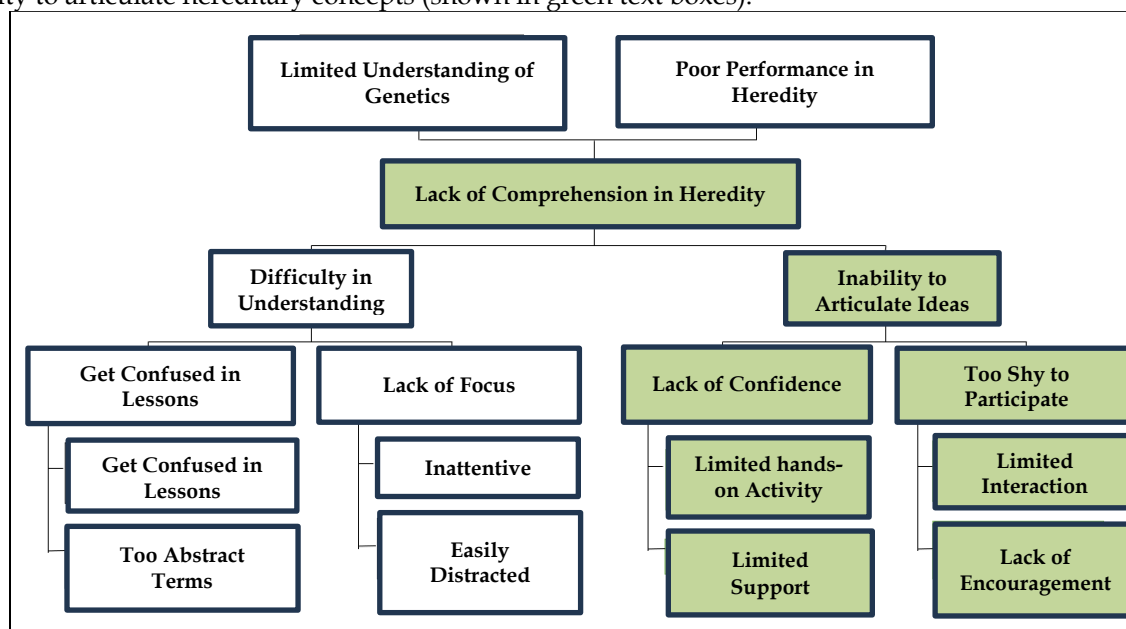


Figure 1. Problem Tree Analysis of Poor Comprehension in Heredity

Articulation, the ability to clearly express one's understanding, is not only a reflection of comprehension but also a contributor to it. Research confirms that effective articulation has a positive impact on learning outcomes and promotes deeper cognitive processing, particularly in science education (Houston & Smith, 2008). From a constructivist perspective, particularly in the context of Piaget's formal operational stage, adolescents are developmentally equipped to handle abstract concepts when provided with appropriate scaffolding (Inhelder & Piaget, 2008). However, reports have shown that at various levels, HOTS-driven questioning is limited (Derico et al., 2018; Magdato & Satparam, 2023).

Given this context, the current action research aims to explore how scaffolding strategies can be used to enhance learners' articulation abilities, thereby improving their comprehension and performance on the topic of genetic mutation. This action research contributes to the teaching and learning theme of the DepEd's basic education research agenda, which examines strategies, best practices, and instructional facilitation. By targeting articulation as a means to foster comprehension, this study seeks to address an urgent pedagogical need and contribute to post-pandemic recovery efforts in science education.

2.0 Methodology

2.1 Research Design

This study employed an action research design to address the articulation ability of the respondents. In the educational context, action research is employed by teachers and school administrators to formulate effective strategies through problem identification, action-taking, and analysis of the corresponding results of an intervention. Instead, the study emphasizes practical instructional insights and rich qualitative patterns. The action research follows Dickens and Watkins' (1999) four-stage cyclic process, which is:

Planning Phase. Considering the time frame of the teaching internship, the researchers conducted the study using only one Most Essential Learning Competency (MELC), i.e., S10LT-IIIe-38, through three daily lesson plans. The lesson focuses on the topic of mutation, a component of heredity at the Grade 10 level. Furthermore, the researchers have utilized the lesson plan to incorporate scaffolding questions, progressing from lower-level to higher-order thinking skills.

Action Phase. The action phase involves implementing the plans formulated in the planning phase through design activities based on the Scaffolding Strategies and Design Framework. The scaffolding strategies from the framework of Land & Zembal-Saul (2003) were implemented, as they aim to design an activity that helps improve the student's articulation ability. As shown in the succeeding table (Table 2), the scaffolding design and framework are composed of three parts: Facilitate ongoing articulation, Support building explanation, and Structure opportunities to organize, reflect upon, and revise. These parts were used as the basis for designing the scaffold.

Observation Phase. The Observation phase co-occurred with the implementation of the action phase. The observers are to look, describe, and record what is happening in the interaction between the participants (the teacher and the students). The participants perform the action phase, while the researchers conduct the observation phase. The observations are structured according to specific variables and were overtly conducted. The critical thinking and communication skills indicator, adapted from Binkley et al. (2012), was used, as its framework was developed throughout the research. The percentage distribution is gathered from the observers' responses of "yes," "no," or "n/a."

Reflection Phase. The reflection phase includes interaction between the participants in terms of what was observed and gathered during and after the implementation (observations and scores). Scores were collected and analyzed according to their Class Proficiency Level (CPL). The observation was conducted in accordance with ethical considerations, including maintaining the confidentiality of students' names and scores. An audio recording has been used to gather students' responses, attitudes, and experiences during the scaffolding activities. Researchers secured informed consent from the participants (students), the principal, and the teacher for recording and conducting the interview.

2.2 Participants

The participants for this research were purposely selected from Baybay National High School, a public school situated in Baybay City, Eastern Visayas, Philippines. Specifically, the study involved 48 Grade 10 learners drawn from a single intact section. These participants were operating under the school's K-12 Basic Education Curriculum, providing a representative context for implementing the scaffolding strategy.

2.3 Research Instrument

The primary data collection instruments included an assessment tool for CPL, a structured observation protocol, video recording devices, and an interview protocol. The quantitative assessment tool, which was content-validated by three experienced science teachers, measured student proficiency in specific Most Essential Learning Competencies (MELCs). Concurrently, a structured observation protocol, adapted from the "Critical Thinking and Communication Skills Indicator" framework by Binkley et al. (2012), was employed to systematically document students' critical thinking and communication skills. To capture rich qualitative data, video recordings were employed to document verbal responses and nonverbal behaviors during scaffolding activities. At the same time, a semi-structured interview protocol, which achieved a content validity index (CVI) of 0.87, was used to gather in-depth insights into students' experiences. Together, these instruments provided a comprehensive mixed-methods approach to evaluating the intervention.

2.4 Data Gathering Procedure

Data for this study were collected in a face-to-face class using a multi-method approach over three consecutive days with one-hour sessions per day following the implementation of the scaffolded activity. Student learning was quantitatively assessed through a daily 15-item quiz (supplied by the resource teacher from the DepEd's learning resource center) administered at the conclusion of each lesson. The quiz served as the measure for CPL. Concurrently, direct observations of participant engagement and interactions were conducted daily, utilizing a pre-established observation protocol (e.g., Binkley et al., 2012) to document the application of strategies and collaborative behaviors. All intervention sessions were video-recorded to capture naturalistic conversations among participants and between participants and the instructor, allowing for in-depth qualitative analysis of their

verbal interactions. Finally, semi-structured group interviews were conducted after the intervention, using a pre-defined protocol to explore participants' perceptions and experiences. All interviews were audio-recorded and transcribed. These diverse data sources were meticulously organized to ensure their integrity and prepare them for subsequent analysis, providing a comprehensive understanding of the intervention's impact.

2.5 Data Analysis Procedure

The efficacy of the scaffolded activity was carefully evaluated through a multi-faceted data analysis approach. The CPL was quantitatively measured once per daily lesson over three consecutive days. These daily CPL scores were subsequently graphed to depict the trajectory of proficiency development following the intervention—a repeated-measures ANOVA was conducted to test whether there was any significant difference across the three days. To enhance the validity of the CPL assessment, data were triangulated across multiple sources: direct observation of participant engagement, excerpts from naturalistic conversations, and semi-structured interviews.

For quantitative analysis, CPL trends were presented graphically, and percent distributions derived from relevant indicators provided further empirical support for observed changes in proficiency, thereby serving as concrete evidence of learning performance. Qualitative data, primarily derived from transcribed video recordings, were systematically tabulated against the established scaffolding framework. This process facilitated the identification of specific instances demonstrating how participants employed the implemented strategies. Furthermore, observational indicators (Binkley et al., 2012) and data from group interviews were subjected to thematic analysis using the method outlined by Clarke and Braun (2013). Thematic analysis involved a six-phase approach: familiarization with the data, systematic code generation, preliminary theme development, rigorous theme review, precise theme definition and naming, and the selection of compelling data exemplars. Themes emerging from this analysis were systematically documented daily to capture evolving patterns.

2.6 Ethical Considerations

This research adhered to stringent ethical guidelines to ensure the safeguarding of participant well-being and data integrity. Informed consent was secured from all participants and their legal guardians following a comprehensive disclosure of the study's objectives, procedures, potential risks, and anticipated benefits. Anonymity and confidentiality were maintained throughout the data collection and analysis phases, with all personal information handled in strict accordance with the Philippine Data Privacy Act of 2012. The intervention was developed to be both engaging and beneficial, thereby minimizing potential harm. Furthermore, participants retained the unequivocal right to withdraw at any point without penalty. Participant selection and research execution prioritized fairness and equity. Rigorous data collection and analysis protocols were implemented to ensure the integrity and reliability of the findings.

3.0 Results and Discussion

The action research aimed to enhance the articulation ability of Grade 10 students in learning genetic mutation by designing an activity that utilized the scaffolding design and framework. As shown in Figure 1, learners demonstrated a consistent improvement in performance, from 73% on Day 1 to 76% on Day 2 and 79% on Day 3. The overall test (day effect) is not statistically significant ($p \approx 0.14$). That means we cannot conclude that there is a reliable difference across Day 1, Day 2, and Day 3 at the 0.05 level, although the upward trend we observed (74% → 76% → 79%) is clearly present. While these figures reflect progress for the three-day intervention, the overall proficiency level of Grade 10 students remained within the 'Developing' category (75-79%).

Nevertheless, the steady increase in the CPL, despite being classified as 'Developing,' indicates that the strategies have the potential to enhance learning performance. The observed improvement, though modest, aligns with the principles of scaffolded instruction, where learners are supported through structured guidance until they reach greater autonomy (Vygotsky, 1978). This implies that articulation skill is beginning to emerge, though not yet fully realized. These findings align with Aykan and Dunkun's (2022) emphasis on the enhancement of performance through active learning processes. Furthermore, the results revealed that pen-and-paper tests may not fully capture learners' growing articulation abilities. However, the consistent upward trend serves as evidence of its potential to enhance comprehension and conceptual understanding, which may later be reflected in how students verbalize genetic concepts.

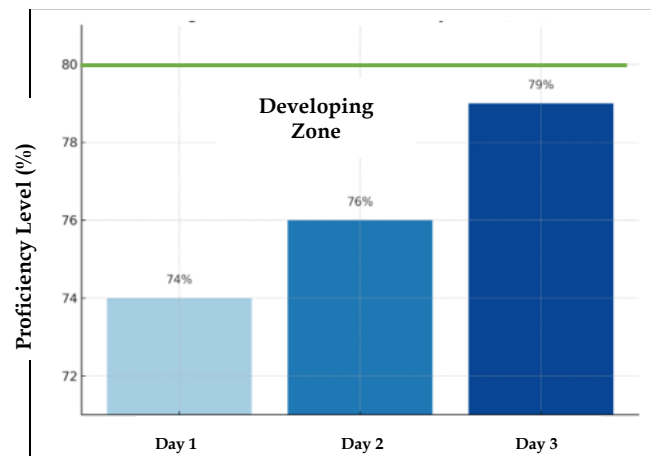


Figure 1. Mean Class Proficiency Level (CPL)

Table 1 shows that there are changes in the percentages from day 1 until day 3. The variation on day 1 came from the observation regarding generating conclusions [critical thinking skills indicator], and fluency and coherence in explaining [communication skills]. To further elaborate, it can be observed that on day 1, students have difficulties in interpreting, analyzing, and drawing conclusions from the concepts they have read, as shown in the percent distribution. The results indicate that learners struggled to interpret the provided data and information. It hinders their ability to process the available knowledge. However, as the activity progresses, their critical thinking skills undergo a remarkable change. On the second day of the intervention, students started to connect ideas more between the topics to teach each other. These changes from the second day to the third day provide evidence of development in critical thinking skills.

Table 1: Percentage Distribution of the Critical and Communication Skills Indicator

	Day 1			Day 2			Day 3		
	Yes	No	N/A	Yes	No	N/A	Yes	No	N/A
Critical Thinking Skill									
1. Using various types of reasoning according to the situation at hand.	100			100			100		
2. Examine ideas and identify.									
3. Synthesize and make connections between information and arguments.	100			100			100		
4. Interpret data and draw conclusions based on analysis.	75	25		100			100		
5. Draw a conclusion.	25	75		33	77		100		
6. Analyze statements, state results, and correct procedures.	100			100			100		
Communication Skills									
1. Able to understand the arguments given by others.	100			100			100		
2. Able to write multiple types of papers or data.			100			100			100
3. Able to read and understand different types of data or writing.	100			100			100		
4. Able to hear and understand various spoken or written languages.	100			100			100		
5. Convey information, ideas, questions, and opinions clearly and easily to understand.	100			100			100		
6. Fluency in conveying information, ideas, questions, and opinions.	75	25		100			100		
7. Convey information, ideas, questions, and opinions coherently.	75	25		100			100		

As the days progressed, students' communication skills showed variation, particularly in their ability to convey information coherently. On Day 1, some learners relied heavily on reading materials and struggled to form original sentences. This reliance decreased by Day 2, with increasing coherence in verbal explanations. These improvements may indicate that structured scaffolding—such as guided peer interactions and targeted

questions—helped learners internalize and reorganize content knowledge for expression. The excerpt presented in Table 2 in the Support explanation-building shows that their reliance on the reading material is more on elaborating on what they have already explained.

The results suggest that the 3-day activity session (i.e., 1 hour per day) may not be sufficient for students to achieve a higher level of proficiency. To improve the literacy and numeracy skills of early-grade learners, Daniela et al. (2023) reported that an 8-week learning recovery program can improve reading competencies. The focus of this study, however, is on the student's ability to articulate. To provide further evidence that the activity enhanced the students' articulation ability, the daily assessment results discussed above are used to address the formulated action research question.

In facilitating ongoing articulation, peer teaching activities were designed with embedded scaffolding questions to prompt learners to verbalize their understanding and effectively communicate it to their peers. As shown in Table 2, these questions required learners to engage in higher-order thinking skills (HOTS), encouraging them to analyze, synthesize, and evaluate. The scaffolding design strategy, grounded in the framework of Land and Zembal-Saul (2003), emphasizes three core components: facilitating ongoing articulation, supporting explanation-building, and structuring opportunities for organization, reflection, and revision. Each of these components is contextually integrated within the instructional design to align with the specific content and objectives of the study. The data revealed that the scaffolding questions effectively stimulated critical thinking, as learners were required to process and apply information at a higher cognitive level. Research suggests that the development of higher-order thinking skills enhances students' critical thinking abilities, which subsequently improves their learning in the science subject (Saputri et al., 2019). As a result, learners were able to utilize the scaffolded questions to articulate their interpretations of the learning materials. An example of scaffolding question and a student's response are presented in Table 2.

Table 2: Scaffolding Strategies and Design Framework with Sample Conversations

Scaffolding Design Strategy	How did we use this strategy?	Sample Conversations
Facilitate Ongoing Articulation	Designed an activity with scaffolding questions that prompt learners at different levels to articulate knowledge of heredity.	Scaffolding Question: (Expert Topic: Mutation) <i>How are these types of mutation different from each other?</i> Translated: <i>The somatic mutation happens in tissues, while the germline mutation happens in gametes – that is, the egg cells and sperm cells. What cells are for females? (asking her group mates) Males produce egg cells and sperm cells. Okay, let us start with somatic [mutation], mostly they do not have noticeable effects on the phenotype – I think it is in the physical [aspect]. However, it is the basis for cancer to form. In germline [mutation], it can be passed onto your child, and onto your child's child if he/she will give birth, like that. - P1</i>
Support Explanation-Building	Designed an activity that provides information (of heredity) that they are to make connections explicitly. Working with small groups promotes better communication with MKOs (teachers and peers) through peer teaching.	Expert Group Topic: Missing in Action Translated: <i>... their way of thinking is unclear [retarded], that is what cri du chat means. They have big eyes and small heads because a part of the fifth chromosome is either deleted or missing. Which chromosomes are affected by the deletion? (asking her group mates). On the fifth right. Look at this, they should be the same in structure, but here there is a missing part (about the photos provided in their reading material). - P2</i>
Structure Opportunities to Organize, Reflect Upon, and Revise	Designed an activity that enables learners to present and explain the concepts they have learned in heredity through a reporting/debate format. Created a progress checklist to help learners track the content they need to learn.	During Debate Translated: <i>So, I will rebut... Yes, we all know that... you said earlier that if the parents of the baby have a genetic disorder, then possibly it can be passed on to their offspring...For instance, I am pregnant, so there will be a great possibility that my child could acquire such genetic abnormalities...through genetic engineering, I can already know and prevent this genetic disorder from being passed on to my child. - P2</i>

In the conversation, the student utilized the HOTS scaffolding question to organize the information acquired as she shared the two main types of mutation with her peers. The student's response demonstrates her ability to differentiate between somatic and germline mutations, providing examples of how these genetic alterations are passed on to offspring. Further, the learner also asked her classmates a follow-up question about the sex cell (egg

cell), “What cells are for females?” This demonstrates her ability to elicit and connect previous information to new learning. More of this conversation is presented in Table 2, which highlights the importance of scaffolding questions as the learner grasps the concept.

The conversations demonstrate how HOTS scaffolding questions helped learners critically process the information they obtained. It is argued that HOTS enhances students’ ability to think critically and analytically, which is said to impact language achievement necessary for effective communication (Antonio & Prudente, 2024; Shafeei et al., 2017). When good questions are provided, the result is meaningful discussions (Ocbian & Pura, 2015). It can be argued that formulating HOTS scaffolding questions as one of the scaffolds has the potential to facilitate students’ ongoing articulation.

To support explanation-building, a peer teaching activity was used as the support device. The activity enabled students to communicate the information provided about genetic mutation, which they needed to connect with, as detailed in the second column of Table 2. Students were assigned to work in smaller groups on expert topics to facilitate more effective communication. The sample conversations from the data demonstrate the importance of the information provided in the reading material, as illustrated in Figure 2, which presents a sample expert topic from Day 2.

As observed in Figure 2, there were pictures about the genetic disorder, and in this example, it was Cri du chat (Acosta et al., 2015). Cri du chat is a genetic disorder caused by a deletion or missing piece in Chromosome 5 that affects a person’s physical and genetic makeup. A person with this disorder may exhibit distinct physical characteristics, including wide-set eyes, a small jaw, and a short stature. The definition of Cri du chat was referenced from the Science 10 Learner’s Material (LM) unit 3. The karyotype image was sourced from Shutterstock.com (<http://bit.ly/4fmEZuN>), and the patient image was adopted from Cerruti (2006). This specific information, as seen in the conversation from Table 2, prompts the learner to utilize the material to communicate her understanding and even ask questions about the concepts to her peers.

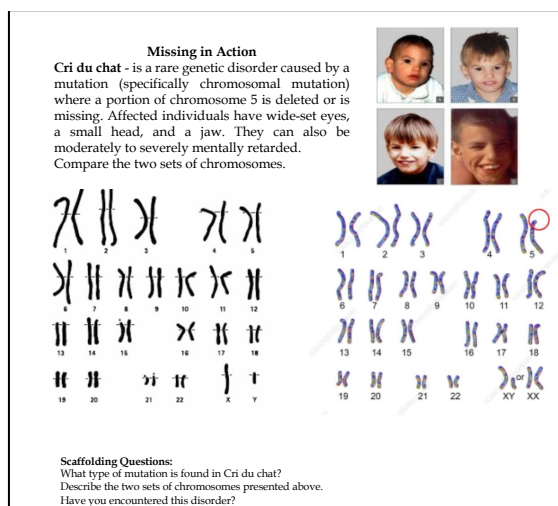


Figure 2. Expert Group Topic from Day 2 of the Sample Conversation

The response demonstrates the application of the information provided in the reading material in making connections to the learner’s ideas. It is undeniably true that learning resources cannot replace excellent teaching, but these instructional materials are ingredients for achieving an effective teaching and learning process (Sambayon et al., 2023). Similarly, a study by Zeipel (2015) suggested that the use of illustrations in science learning has prompted a comprehensive scientific discussion. Furthermore, communicating their learned knowledge becomes possible as they work with smaller groups, exchanging ideas and asking questions confidently about the topic to their peers (see Table 2). Since there were enough members in an expert or home group, all learners were allowed to communicate and explain what they had learned. It can be observed that smaller groups promote better communication as these allow learners to share, ask questions, and exchange ideas comfortably. Small groups are seen as encouraging social interaction among those who are reluctant to speak and enabling all members to contribute to the learning process (Johnson et al., 2014).

Moreover, data from observations depicted how the explanation-building strategy was supported. The observations revealed that students gradually improved over time, based on four key themes: articulation, cognition, participation, and confidence, highlighting a trajectory of learner growth over time. Initially, students appeared hesitant and unclear in their explanations; however, by Day 3, they demonstrated greater fluency, confidence, and a willingness to participate. These transitions suggest that the reported peer-teaching structure, supported by scaffolds, contributed to improved articulation, as learners appear more willing and able to process and communicate their expert topic.

As the scaffolding strategies were implemented, there was a transition from struggling to articulate ideas to being capable of conveying them effectively. Emerging themes and codes from the comments show that students struggled as they participated in the activity for the first time. These are the example comments from observations revealing learners' difficulties:

"Struggles sharing despite fluency in English and vernacular language. Only a few were able to communicate with fluency." - O4.

"The connections were not obvious as the time was consumed figuring out what they were doing in the activity." - O1.

Since the activity was new to learners, they took time "figuring out what they were doing in the activity". As a result, they struggled to make connections between ideas about heredity, specifically the topic of mutation, within the allotted time frame. Likewise, some students were "disinterested in participating..." due to the unfamiliarity of the intervention, which resulted in slower comprehension, preventing learners from articulating their expert topic with ease. However, as the day progressed, observers noted changes in students' ability to express and articulate concepts. It can be observed that the students transitioned from being unfamiliar with the activity to becoming familiar with it, which helped learners in their explanation and expression of ideas. Positive observation samples of the comments from the different themes on days 2 and 3 are as follows:

"Some of the students fully grasp their topic, which is why it is very easy for them to share their knowledge with the next groupings [from expert group to home group]." - O1

"Since the instructional material or handouts consist of illustrations, definitions, and examples, they were able to examine and identify comprehensively." - O2.

"Although there are a few who are disinterested in participating...they still manage to cooperate since they are obliged to teach it to their classmates." - O1

"I observed that students gained much confidence in explaining their expert concept..." - O2

The observations suggest a noticeable improvement in learners' ability to articulate by days 2 and 3, particularly in their confidence and fluency during group discussions. The peer-teaching activity enables learners to share and exchange knowledge with one another, becoming more knowledgeable others (MKOs) in their respective groups. Since all students were said to be MKOs in the concept they are assigned to, this contributes to their confidence in explaining their expert concept to their peers. In addition, reading materials were also beneficial to the activity, "since instructional materials or handouts consist of illustrations, videos, definitions, and examples" as shown in Figure 3, which are essential in their comprehension of the concepts.

Having a smaller group size contributes to effective communication as students can comfortably share their learning with their peers. Additionally, through this type of grouping, each member is assigned the responsibility to teach their classmates, which holds them accountable not only for their own learning but also for their classmates. The peer tutoring activity has driven them to cooperate and participate "since they are obliged to teach". Giving learners responsibility appeared to encourage their motivation and participation during the activity, which could support personal growth if sustained over time (Fishman, 2014).

Along with the comments from the observers, emerging themes, such as articulation and cognition, from the interviews shown in Table 3 also indicate that students are experiencing struggles in articulating their ideas as the intervention begins. The following are the responses from students as the strategy began, which show challenges

in articulation:

"My other classmates had different and difficult ways of explaining their expert topics, thus we did not learn much from them."- P1

"I hoped that all members would comprehend their topic so that when we regrouped into the home group, they could also teach properly."- P2

"It is unfair since we have other members who cannot explain and express what they have learned." - P3.

The responses suggest that their peers' inability to express their learning had led them to yearn for a more effective and thorough teaching of the topic. Regardless of such difficulty, students were able to continue with the activity, knowing that there was importance in sharing their topic. An example of a response like "We strive hard for us to be able to share our learning" shows students' desire to teach their peers. As the intervention progressed, students became familiar with the peer teaching activity, and particular reflections or realizations emerged in the themes, including responsibility, motivation, and self-satisfaction. Relevant responses are as follows:

"The good thing about this experience is that we get to use this in the future. That is how to teach others, by comprehending the topic first." - P2

"It is important to listen to the group mates (in the expert group) so that in the next group (home group), there will be ideas that can be shared." - P1.

"I felt happy that I could explain and share with my classmates what I know. I feel satisfied." - P2

"The good thing about this experience is that we get to use this in the future. That is how to teach others, by comprehending the topic first." - P2

"It was good because it makes us diligent because we really need to make an effort in explaining" - P3.

These learner reflections suggest that scaffolding may support not only cognitive articulation but also short-term affective outcomes, such as motivation and responsibility, which are factors associated with long-term engagement in science learning. A study has shown that engaging in dialogue that fosters a friendly environment also boosts confidence and improves cognitive abilities (Arzaga, 2021; Bombardelli, 2016). Moreover, according to Bloom's Taxonomy in the affective domain, the valuing level is concerned with the worth students attach to something they have learned. The valuing level is third among the six levels of this hierarchical domain, indicating that as the level increases, the student becomes more involved, committed, and motivated.

In addition to quantitative gains, qualitative data revealed a noticeable shift in students' affective engagement with the lesson. Analysis of participant responses suggests a progression along Krathwohl's (1964) affective domain taxonomy—from receiving (demonstrating willingness to attend to the task) and responding (actively participating) toward valuing (expressing appreciation or commitment to the content and activity). This progression was evidenced in students' increased ownership of their learning, particularly in their reflective comments and willingness to engage in peer discussions.

One emergent theme, presented in Table 3, was time management, which highlighted both a challenge and an opportunity for refining the intervention. Several students expressed difficulty in completing tasks within the allotted time, pointing to the need for more explicit structuring of group roles and pacing cues. This insight suggests that scaffolding strategies could be enhanced through the incorporation of explicit time checkpoints, streamlined activity breakdowns, and reinforced use of progress monitoring tools such as the "expert topic checklist." These refinements would help learners not only stay on task but also better regulate their own learning process—an essential step in moving from guided participation to autonomous performance.

In this context, time management does not merely represent a procedural concern but also reflects students' developing capacity for self-regulation and goal-directed behavior—affective outcomes that are integral to successful science learning and communication.

Table 3. *Themes and Codes from the Interviews*

Themes	Codes
Articulation	Difficulties in their classmates' way of explanation, Sharing of ideas, Inability of others to explain, Able to brainstorm together, Shared little ideas, Unable to explain coherently, Can explain with guidance, Able to explain materials provided, Strive hard to be able to share, Inaccuracy of explanation,
Cognition	Teaching through understanding, Understanding a concept of the more knowledgeable, Struggles in understanding/ comprehending, Slow learner, Can answer questions by comprehending, Easily understand concepts through peer-teaching, Learning by teaching, Peer-teaching is an easy and comfortable way of learning, Unable to comprehend the topic,
Responsibility	Responsibility in learning, Accountability in teaching, A test in teamwork and unity, Preparation for the future, Becoming a more knowledgeable other, Becoming a role model, Irresponsible learner, Not paying attention or not listening, Able to explain through collaboration, Good way of making students diligent.
Motivation	Enjoyment in the discussion, Difficult but fun, Attentive to the discussion, Excitement in learning from peers, Discouragement from classmates, Not participating in explaining
Confidence	Development of social skills, Building of self-confidence, Development of good communication skills, Comfortable with asking questions, Fear of sharing with others, Do not interact due to shyness.
Self-satisfaction	Satisfaction in sharing the knowledge, Excitement in teaching others
Time Management	Taking initiative due to time constraints means having enough time to learn. There should be proper time management.

In the structure, opportunities for learners to organize, reflect upon, and revise their strategies were applied in various ways, including conducting daily assessments, performance assessments (reporting & debate), and creating a progress checklist. The performance assessments have enabled learners to organize the information learned throughout the learning competency by recalling or reviewing group discussions and planning the content to be reported. The debate (refer to Table 2) also allowed students to practice the skills they had acquired by participating in the activity.

The progress checklist, on the other hand, has allowed learners to reflect on their productivity throughout the activity. The checklist, which contains additional scaffolding questions, will enable students to make connections between the topics and what they have learned. Making connections or concluding, however, was not very evident during the first day of the intervention due to the insufficient time available. For this reason, this struggle can be warranted by students' unfamiliarity with how the activity was supposed to flow. As the students understood the purpose of the activity, they were able to navigate it more effectively with the help of the checklist.

The pedagogical considerations in scaffolding learners include creating HOTS questions or guide questions and providing instructional materials that support the learning process. Based on the intervention, it is essential that questions target upper levels of the cognitive domain of Bloom's Taxonomy, stimulating learners' critical thinking skills so that they understand the concept and make connections to their learning (Krathwohl, 2002; Sumayao & Niez, 2016). Instructional materials should align with the learning objectives and consider the diverse needs of the students, i.e., handouts, videos, pictures, and other online tools. In addition, the scaffolds can be applied not only in learning about genetic mutation but also in other topics within the science subject.

The findings of this study are inherently context-bound, reflecting the unique dynamics of a Grade 10 class engaged in a three-day scaffolded intervention on genetic mutation. As is characteristic of action research, no inferential statistical procedures were applied; thus, the results are not intended for generalization to broader populations. However, the credibility of the findings was bolstered through data triangulation, thematic analysis of qualitative responses, and corroboration from direct classroom observations and learner reflections.

Rather than claiming universal applicability, this study offers valuable, situated insights into how scaffolded instruction can support the development of learners' articulation skills in complex scientific contexts. The short duration of the intervention is acknowledged as a limitation. However, it also demonstrates that even brief, well-structured scaffolding strategies can initiate meaningful shifts in both comprehension and communicative

engagement. These findings contribute to the ongoing conversation about post-pandemic science education, where articulation and understanding are critical for learner recovery and resilience. Future cycles of this research can build on these initial outcomes by expanding the duration, deepening the assessment tools, and examining how articulation development unfolds over time across different scientific domains.

4.0 Conclusion

This action research study investigated the efficacy of a scaffolded learning intervention in enhancing the articulation ability of Grade 10 learners, particularly within the challenging context of genetic mutation. While direct translation to written assessment scores was not consistently observed, the triangulated findings from structured observations, conversation excerpts, and qualitative analyses of video recordings indicate development in participants' articulation skills. Specifically, the implementation of the Land and Zembal-Saul (2003) scaffolding framework, characterized by the teacher's deliberate facilitation of higher-order thinking skills questions, active support for collaborative explanation-building (e.g., through peer-teaching), and structured opportunities for organizing, reflecting upon, and revising understanding (e.g., via performance assessments and progress checklists), proved instrumental in fostering this improvement.

These findings suggest that such scaffolded instructional approaches possess the potential to address the inherent complexities of content-specific terminology, abstract concepts, and theoretical frameworks prevalent in subjects like heredity. The observed development in articulation ability aligns with theoretical underpinnings, particularly Vygotsky's Zone of Proximal Development (ZPD) and Bruner's Scaffolding Theory, which posit that learners' cognitive growth is best supported through guided assistance that bridges the gap between their current and potential levels of understanding.

Given these insights, it is recommended that educators consider incorporating theoretically grounded scaffolding strategies into the teaching of other complex scientific domains. Furthermore, the findings underscore the importance of utilizing different assessment modalities, particularly performance-based assessments, as highly appropriate tools for accurately evaluating learners' nuanced articulation abilities, which traditional written evaluations may not fully capture. Future research could explore the longitudinal effects of sustained scaffolding interventions on both articulation and conceptual understanding across various scientific disciplines.

5.0 Contribution of Authors

All authors contributed equally to the development and completion of this work.

6.0 Funding

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7.0 Conflict of Interest

The authors state no conflict of interest.

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