# Development and Validation of GenEduKit as a Supplementary Instructional Material for Teaching Genetics

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## ABSTRACT

Genetics remains a challenging topic in Biology because it involves abstract concepts, symbolic representations, and problem-solving tasks that learners often find difficult to understand. This study aimed to develop and validate the Genetics Educational Kit, or GenEduKit, as a hands-on instructional material for teaching introductory genetics among Grade 8 learners in a rural public-school context. Using a developmental research design with quantitative and qualitative evaluation approaches, the study was based on preliminary needs assessment results, in-service science teachers' insights and curriculum alignment. Results showed that Heredity: Inheritance and Variations obtained 39%, indicating that genetics-related concepts remained difficult for learners. The teachers' responses revealed that learners had difficulty understanding abstract genetics concepts, distinguishing genotype and phenotype, identifying dominant and recessive traits, solving Punnett square problems, predicting offspring traits, and interpreting genetic outcomes. In response, the GenEduKit was developed as a printed and manipulative instructional material composed of a learner's worksheet/manual, teacher's guide, Punnett square board, parent genotype cards, trait cards, trait discs, activity worksheets, and assessment materials. Validators' comments were used to improve the clarity, durability, usability, visual consistency, assessment, and critical-thinking component of the kit. Overall, the developed GenEduKit may serve as an accessible, low-technology, reusable, and learner-centered supplementary material for genetics instruction. However, since the study primarily focused on the development and validation of the GenEduKit, further classroom implementation and experimental testing are needed to determine its effectiveness in improving learners' genetics learning outcomes.

Keywords: GenEduKit, genetics education, hands-on learning, instructional material, rural school, developmental research

## INTRODUCTION

Science education plays a vital role in preparing learners to think critically, analyze data, and solve real-world problems. However, recent global assessments reveal that the Philippines continues to face major challenges in achieving quality science education. According to the Programme for International Student Assessment 2022, Filipino students scored an average of 356 in science, significantly below the OECD average of 485. These results underscore the need for effective and innovative strategies to strengthen science literacy and equip learners with essential 21st-century skills.

Within the field of science, genetics is a particularly essential yet challenging area for students to master. Genetics is one of the most conceptually demanding topics in biology because it involves abstract and microscopic processes, such as gene expression, inheritance patterns, and chromosomal behavior, which students cannot directly observe. Studies have shown that learners commonly struggle with differentiating genes from

chromosomes, predicting monohybrid crosses, interpreting Punnett squares, and understanding dominant-recessive relationships, leading to persistent misconceptions and low achievement in genetics.

In response to these issues, this study aimed to develop a genetics educational learning kit in genetics, known as GenEduKit. The GenEduKit was designed as a hands-on educational package intended to enhance conceptual understanding and engagement in genetics among Grade 8 learners. It included a teacher's guide, learner's worksheet/manual, and supplementary learning materials such as a Punnett square board, trait cards, parent genotype cards, and trait discs. The kit was aligned with the K to 12 Science Curriculum and was developed based on the identified learning gaps in Biology and teachers' insights on learners' difficulties and needed instructional strategies in genetics.

# METHODOLOGY

This study used a developmental research design with quantitative and qualitative evaluation approaches. It focused on the development and validation of the GenEduKit as a hands-on instructional material for teaching genetics among Grade 8 learners. The development process began with the review of preliminary needs assessment results, teachers' observations, and the K to 12 Science Curriculum. These served as the basis for identifying the genetics concepts and instructional supports to be included in the material.

The GenEduKit was designed as a printed and manipulative instructional material intended to support learners in understanding inheritance patterns, distinguishing genotype and phenotype, identifying dominant and recessive traits, and solving Punnett square problems. The developed material included a learner's worksheet/manual, teacher's guide, Punnett square board, parent genotype cards, trait cards, trait discs, activity worksheets, and assessment materials. These components were prepared to provide visual, hands-on, and guided learning experiences in genetics.

After the initial development of the GenEduKit, the material was subjected to expert validation. Their comments and suggestions were gathered and analyzed to determine the parts of the GenEduKit that needed revision. The quantitative validation results were analyzed using mean and descriptive interpretation, while the qualitative comments and suggestions were summarized to guide the improvement of the material.

# RESULTS AND DISCUSSION

### Basis for the Development of the GenEduKit

The development of the GenEduKit was guided by the preliminary needs assessment, in-service science teachers' insights and curriculum alignment. The preliminary needs assessment showed that Heredity: Inheritance and Variations obtained 39%, indicating that genetics-related concepts remained difficult for learners.

This result served as the initial basis for selecting genetics as the focus of the developed instructional material. This is consistent with Santos et al. (2021), who emphasized that least-mastered Biology competencies can serve as a basis for developing instructional interventions.

Similarly, Macalikod and Simpal (2025) emphasized that science instructional materials may be developed from least-learned competencies to provide structured support for learners who struggle with specific science concepts.

After identifying genetics as the area needing support, the teacher survey was examined to determine the specific learning difficulties and instructional needs of learners in genetics.

Table 1. Summary of In-Service Science Teachers' Insights as Basis for GenEduKit Development

| Theme | Statement | Meaning |
|---|---|---|
| 1. Conceptual Difficulties in Genetics | "Students usually experience difficulties in understanding abstract concepts such as genes, alleles, dominant and recessive traits" (NA-T1), "Students struggle with abstract concepts like inheritance patterns, genotype vs. phenotype"(NA-T2),"Some students confuse genotype and phenotype or have trouble visualizing processes they cannot directly observe" (NA-T3) | Learners have difficulty understanding abstract genetics concepts and visualizing genetic processes that cannot be directly observed. |
| 2. Misconceptions on Dominant and Recessive Traits | "Identifying dominant and recessive traits" (NA-T1), "Misconceptions about dominant and recessive traits are common" (NA-T2) | Learners need clearer explanations and concrete examples to understand how dominant and recessive traits are expressed and inherited. |
| 3. Difficulty in Solving Punnett Squares | "Students usually have difficulty understanding inheritance patterns, especially in solving Punnett square" (NA-T1), "solving Punnett squares" (NA-T2), "Many also struggle with solving Punnett squares, predicting inheritance patterns" (NA-T3) | Learners need guided practice in organizing genotypes, completing Punnett squares, and predicting inheritance patterns. |
| 4. Difficulty in Probability, Analysis, and Interpretation | "Mathematical aspects of probability in predicting traits can be challenging for learners" (NA-T2), "Applying probability in genetics problems" (NA-T3), "Especially when predicting traits and interpreting results" (NA-T4) | Learners need support in applying probability, analyzing genetic crosses, and interpreting results. |

The teachers' responses showed that learners experienced both conceptual and procedural difficulties, particularly in understanding abstract genetics concepts, distinguishing genotype and phenotype, identifying dominant and recessive traits, solving Punnett square problems, predicting inheritance patterns, applying probability, and interpreting results.

These teacher-identified difficulties became the primary basis for identifying the concepts and activities to be included in the GenEduKit. Similar local genetics studies also reported that learners encounter difficulty in Mendelian and non-Mendelian genetics because of abstract concepts, unfamiliar terms, and the need for higher-order reasoning (Barrientos et al., 2024; Laguindab et al., 2025). Newman et al. (2021) also noted that learners often associate gene expression and inheritance mainly with Punnett squares and phenotypic outcomes, which suggests the need for instructional support that helps learners connect symbolic representations with deeper genetic concepts.

**Development and Validation of the GenEduKit**

The GenEduKit was developed as a printed and manipulative instructional material intended to support Grade 8 learners in understanding introductory genetics concepts. It was designed to make abstract genetics concepts more concrete through visual, guided, and hands-on activities. The kit focused on helping learners understand inheritance patterns, distinguish genotype and phenotype, identify dominant and recessive traits, and solve Punnett square problems. This design is supported by studies emphasizing that supplementary and instructional materials should be aligned with learners' difficulties, curriculum standards, and classroom needs to improve their relevance and usability (Lituañas & Dela Cruz, 2024; Pinuela, 2025).

Table 2. Expert Feedback and Revisions Made on the GenEduKit

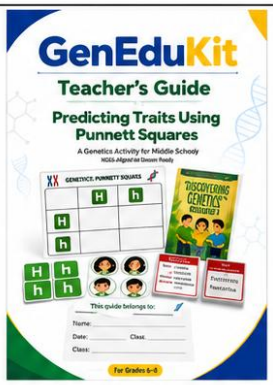
| Validators comments/suggestions | Revision Made | Purpose |
|---|---|---|
| 1. Some words used in the materials needed to be simplified. | Simplified the words used in the learner's worksheet/manual, activity instructions, and related GenEduKit materials. | To make the directions and genetics concepts easier for Grade 8 learners to understand. |
| 2. Some materials needed to be more durable for repeated classroom use. | Changed or improved the supplementary materials using more durable materials. | To ensure that the GenEduKit can be used for more than one month and can withstand repeated handling during group activities. |
| 3. The group activity needed a clearer scoring guide. | Added a rubric for scoring the group activity. | To provide clear criteria for assessing learners' participation, accuracy, cooperation, and explanation of results. |
| 4. The function of each material needed to be explained more clearly. | Added clearer descriptions of the purpose and use of each GenEduKit component. | To help teachers and learners understand how each material should be used during the activity. |
| 5. The design of the instruction manual needed to match the supplementary materials. | Revised the design of the instruction manual to fit the appearance and organization of the supplementary materials. | To make the GenEduKit more visually consistent, organized, and learner-friendly. |
| 6. The activity needed to encourage more critical thinking | Added incorrect trait discs as distractors in the activity. | To encourage learners to analyze, compare, and justify their answers before selecting the correct offspring traits. |

After the initial version was prepared, revisions were made to improve the GenEduKit's clarity, durability, organization, usability, and classroom readiness. These included simplifying words and instructions, using more durable materials, adding a scoring rubric, clarifying the function of each component, redesigning the instruction manual, and adding incorrect trait discs as distractors to promote analysis and critical thinking. These revisions resulted in Version 2 of the GenEduKit, which was prepared for validation and classroom implementation. The revision process shows the importance of expert validation in improving the quality, accuracy, appropriateness, and classroom usability of instructional materials (Lituañas & Dela Cruz, 2024; Soriano, 2024).

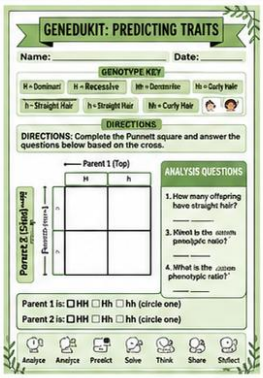
The instrument obtained an overall mean of 4.79, interpreted as Very Good. This indicates that the instrument was generally acceptable and appropriate for use in the study. Among the criteria, Clarity and Directions of Item and Objectivity obtained the highest mean of 5.00, both interpreted as Excellent. This suggests that the directions of the instrument were clear and that the items were objectively presented. Meanwhile, Adequateness of Items obtained the lowest mean of 4.50, although it was still interpreted as Very Good. Overall, the results show that the instrument was suitable for use, with only minor areas for improvement.

Table 3. Final Version of Components and Functions of GenEduKit

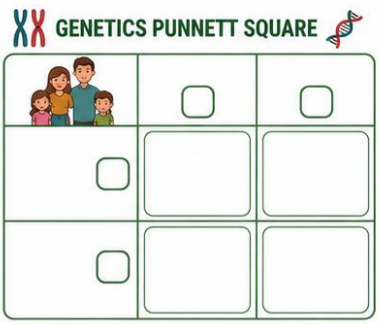
**Components and Functions**



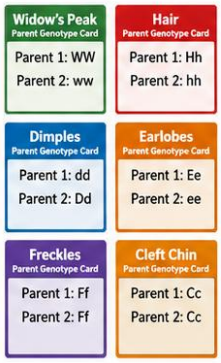

**(A) Teacher's Guide**
Provides instructions and guidance for facilitating the activity




**(B) Learner's Worksheet**
Guides learners in recording answers and completing genetics tasks




**(C) Learner's Worksheet**
Serves as a workspace for determining possible offspring outcomes




**(D) Parent Genotype Cards**
Presents the parental allele combinations used in each genetic cross.


**(E) Trait Cards**
Shows the traits and their corresponding dominant and recessive alleles


**(F) Trait Discs**
Represents possible offspring traits based on the completed Punnett square

The GenEduKit consisted of printed and manipulative materials designed to make genetics concepts more concrete. Its teacher's guide, learner's worksheet, Punnett square board, parent genotype cards, trait cards, and trait discs helped learners organize, visualize, and practice inheritance patterns and offspring trait prediction. Since genetics involves symbolic and abstract concepts, the use of concrete and guided materials may help learners visualize relationships among alleles, genotypes, phenotypes, and offspring outcomes. This supports the role of GenEduKit as a supplementary instructional material that can make introductory genetics more accessible to Grade 8 learners.

## CONCLUSION

This study developed and validated the GenEduKit as a hands-on instructional material for teaching introductory genetics among Grade 8 learners in a rural public-school. The development of the material was based on the preliminary needs assessment, in-service science teachers' insights, and curriculum alignment. These findings showed the need for instructional support in understanding inheritance patterns, distinguishing genotype and phenotype, identifying dominant and recessive traits, solving Punnett square problems, predicting offspring traits, and interpreting genetic outcomes.

The GenEduKit was developed as a printed and manipulative instructional material composed of a learner's instruction manual, teacher's guide, Punnett square board, parent genotype cards, trait cards, trait discs, activity worksheets, and assessment materials. Validators' comments and suggestions were used to improve the kit by simplifying words, improving material durability, adding a group activity rubric, clarifying the function of each component, revising the instruction manual design, and adding incorrect trait discs to promote critical thinking.

Overall, the developed GenEduKit may serve as an accessible, low-technology, reusable, and learner-centered supplementary material for genetics instruction.

However, since the study primarily focused on the development and validation of the GenEduKit, its effectiveness in improving learners' learning outcomes was not fully determined. Further classroom implementation and experimental or quasi-experimental testing are needed to establish stronger evidence of its impact on learners' conceptual understanding and problem-solving skills in genetics.

## RECOMMENDATIONS

Based on the development and validation of the GenEduKit, the following are the future directions of the study:

1. Conduct a learners' needs assessment survey to support the teachers' needs assessment survey in future studies. This will help validate teachers' observations by directly identifying learners' own difficulties, experiences, and support needs in genetics.
2. Conduct pilot testing among Grade 8 learners to check the clarity, usability, time allotment, and appropriateness of the GenEduKit in an actual classroom setting.
3. Gather learner and teacher feedback after extended classroom use to further improve the content, activities, instructions, materials, and assessment rubric of the GenEduKit.
4. Implement the GenEduKit in future classroom studies using experimental or quasi-experimental research designs to determine its effectiveness in improving learners' conceptual understanding, problem-solving skills, engagement, and learning experiences in genetics.
5. Future studies may include pre-test and post-test assessments and, when possible, a control or comparison group to provide stronger evidence of the GenEduKit's impact on learners' learning outcomes.
6. Future researchers may involve larger and more diverse groups of learners from different schools to enhance the generalizability of the findings.
7. Maintain the GenEduKit as an accessible, low-technology, durable, reusable, and teacher-friendly instructional material suited for rural public-school settings.

### Ethical Considerations

The study secured permission from school authorities and ensured voluntary participation. Learners' responses were kept confidential and used only for research purposes. The GenEduKit activities were conducted safely and respectfully.

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