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Mathematics Performance, Reading Comprehension and Problem-Solving Skills of Second Year High School Students in Genetics

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ABSTRACT

This study examined the relationships among Mathematics performance, reading comprehension, and problem-solving skills in Genetics among second year high school students. A non-experimental causal-comparative design with correlational analyses was used. Sixty students from three sections of Sergio Osmeña Sr. High School during School Year 2012-2013 were randomly selected. Mathematics performance was based on first- to third-quarter grades, while reading comprehension and Genetics problem solving were assessed using validated 50-item teacher-made tests. Data were analyzed using descriptive statistics, analysis of covariance (ANCOVA), Pearson product-moment correlation, and multiple regression. Mean Mathematics performance was 81.73, while mean reading comprehension and Genetics problem-solving scores were 29.53 and 30.27, respectively. Mathematics performance significantly differentiated Genetics problem-solving scores, $F = 3.374163$, $p = .041475$, and reading comprehension likewise showed a significant main effect, $F = 6.518109$, $p = .002882$. Reading comprehension was very highly correlated with Genetics problem solving ($r = .8132$), while Mathematics performance correlated moderately highly with reading comprehension ($r = .7477$) and Genetics problem solving ($r = .7128$). The regression model explained about 69% of the variance in Genetics problem-solving scores ($R^2 = .68983861$), with reading comprehension emerging as the strongest predictor. The findings indicate that successful Genetics problem solving depends not only on mathematical competence but also on the ability to comprehend technical text and problem situations. The study supports stronger integration of reading-comprehension instruction with Mathematics and Biology teaching.

Keywords: *Genetics education, Mathematics performance, problem solving skills, reading comprehension, science education, secondary students*

INTRODUCTION

Problem solving is central to science learning because it requires students to retrieve relevant knowledge, interpret problem conditions, select appropriate procedures, and evaluate possible solutions. In Genetics, these demands are especially pronounced because many problems combine biological concepts with probability, ratios, symbolic representations, and technical vocabulary. The source study noted that Genetics is frequently perceived as one of the more difficult areas of school Biology because learners must coordinate domain-specific language with mathematical reasoning (Bahar et al., 1999; Duncan & Reiser, 2007; Law & Lee, 2004).

The need to strengthen these skills was consistent with Philippine curriculum goals that emphasized functional literacy, logical thinking, communication, decision-making, and problem solving in science. Earlier national assessment results cited in the thesis also indicated persistent weakness in Mathematics, Science, and reading comprehension, reinforcing the need to understand how competencies from different learning areas interact (Department of Education, 2002). Because Genetics problems are commonly presented in written form, learners must first understand the problem situation before they can apply a mathematical or biological procedure.

Previous research has shown that mathematical word-problem performance and reading comprehension are closely connected. Fuchs and Fuchs (2002) found that mathematical problem solving and reading difficulties frequently co-occur, while Jordan et al. (2002) showed that reading difficulties can constrain growth in Mathematics. Pape (2004) likewise approached mathematical problem solving from a reading-comprehension perspective. These findings are relevant to Genetics because its problem-solving tasks are often word-based, quantitative, and conceptually dense.

The research gap identified in the thesis was the limited attention given to the joint relationship of Mathematics performance, reading comprehension, and Genetics problem solving, particularly in secondary Biology. Most related studies were situated in Mathematics, English, or Psychology, while fewer examined Genetics as an interdisciplinary problem-solving domain. The present study therefore focused on second year high school students at Sergio Osmeña Sr. High School and investigated whether Mathematics performance and reading comprehension were associated with, differentiated, and predicted students' problem-solving skills in Genetics.

Specifically, the study described students' Mathematics performance, reading comprehension, and Genetics problem-solving skills; tested differences in problem-solving performance when students were grouped by Mathematics performance and reading comprehension; examined the relationships among the three variables; and identified the strongest predictor of problem-solving skills in Genetics. The findings were intended to inform teachers, school administrators, parents, and curriculum planners regarding the need to coordinate reading, Mathematics, and Science instruction.

Literature Review

Problem Solving in Genetics

Genetics problem solving requires learners to reason through abstract biological mechanisms while also applying symbolic and quantitative procedures. Stewart (1982, 1983) documented difficulties experienced by high school students in Mendelian Genetics and emphasized the distinctive reasoning demands of Genetics problems. Smith (1988) similarly distinguished successful from unsuccessful approaches to classical genetic pedigrees. These studies support the view that Genetics problem solving is not a single computational act but a coordinated process involving conceptual understanding, representation, and strategic reasoning.

Learner difficulty is intensified by the terminology and representational complexity of Genetics. Bahar et al. (1999) described Biology learning difficulties and showed that Genetics presents substantial conceptual and vocabulary demands. Duncan and Reiser (2007) further demonstrated that molecular Genetics requires students to reason across distinct levels of biological organization, while Law and Lee (2004) explored how iconic modeling can support the learning of Genetics concepts. These findings explain why students may understand isolated facts yet still struggle to translate a written Genetics situation into a correct problem-solving procedure.

Technology and carefully structured representations have also been used to help learners visualize inheritance relationships. Tsui and Treagust (2003), for example, reported the use of computer-based representations in Genetics learning. Such work reinforces the importance of helping learners connect verbal descriptions, symbols, diagrams, and quantitative relationships when solving Mendelian and non-Mendelian problems.

Mathematics Performance and Scientific Problem Solving

Mathematical knowledge contributes directly to Genetics because probability, ratios, and basic operations are embedded in many inheritance problems. Polya (1973) framed problem solving as a process of understanding the problem, planning, carrying out the plan, and checking the result. In classroom contexts, Fuchs et al. (2003)

showed that structured problem-solving strategies can improve Mathematics performance, while Gersten and Chard (1999) emphasized foundational number sense for learners experiencing mathematical difficulty.

Research has also demonstrated that mathematical problem solving varies according to the learner's ability to interpret and organize the information presented. Jordan and Hanich (2000) and Jordan and Montani (1997) documented differences in mathematical thinking and cognitive arithmetic among children with different patterns of learning difficulty. Nunokawa (2005) further emphasized that mathematical problem solving is a learning process through which students develop ways of understanding mathematical relationships, not merely a test of computation.

These findings are directly relevant to school Genetics, where learners must translate biological conditions into numerical relationships. The source thesis therefore treated Mathematics performance as an important explanatory variable and grouped students according to their Mathematics grades before comparing their Genetics problem-solving scores.

Reading Comprehension and Problem Solving

Reading comprehension involves constructing meaning from written information, identifying relationships among ideas, and applying prior knowledge to the text. Guszak (1972) described reading comprehension as a set of thinking processes that operate during and after reading. When a problem is communicated through text, comprehension becomes an essential first step because the learner must determine what information is given, what is being asked, and which relationships are relevant.

The relationship between reading and mathematical problem solving has been repeatedly documented. Fuchs and Fuchs (2002) reported distinct problem-solving profiles among learners with Mathematics disabilities with and without reading disabilities. Jordan et al. (2002) showed that reading difficulty predicted slower growth in Mathematics, and Pape (2004) examined middle-school problem-solving behavior from a reading-comprehension perspective. Bernardo (1996, 1999, 2005) likewise explored the role of language in mathematical word problems, demonstrating that linguistic representation can influence how learners understand and model quantitative situations.

For Genetics, this relationship is especially important because technical words such as allele, genotype, phenotype, dominance, and inheritance patterns carry precise scientific meanings. A learner who cannot accurately comprehend a problem statement may select an incorrect procedure even when mathematical skills are adequate. The source study therefore hypothesized that reading comprehension would be associated with and could predict Genetics problem-solving performance.

Integrated Perspective and Conceptual Framework

The reviewed literature indicates that problem solving emerges from the interaction of conceptual knowledge, mathematical reasoning, and language comprehension. Bahar (2002) emphasized the need to address the sources of difficulty in Biology learning, while Gersten and Jordan (2005) highlighted the importance of early identification and support for mathematical difficulties. In an integrated Science context, these perspectives suggest that students may require simultaneous support in understanding technical language, organizing information, and applying quantitative reasoning.

The conceptual framework of the study therefore positioned problem-solving skills in Genetics in relation to Mathematics performance and reading comprehension, while the respondents' age and grades in English, Mathematics, and Biology were also considered. The framework reflected the assumption that the variables are interrelated and that differences in performance across these areas may help explain students' success in Genetics problem solving.

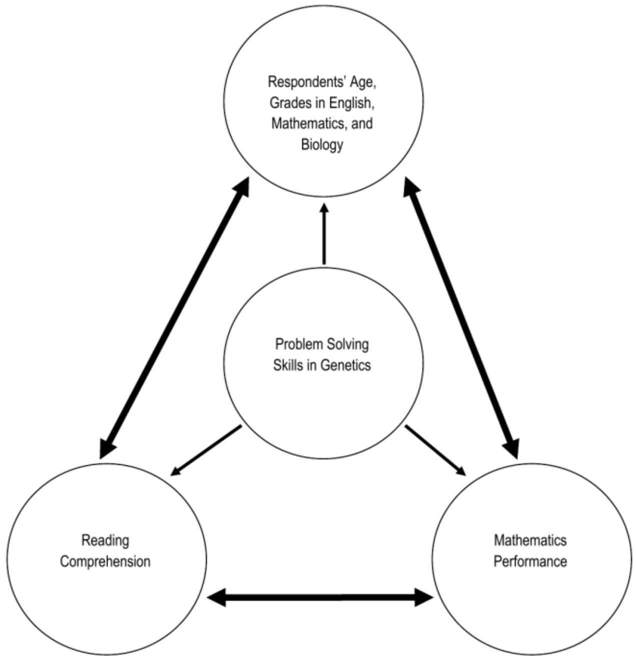

Figure 1. *Conceptual Framework*

METHODS

Research Design

The study used a non-experimental causal-comparative (ex post facto) design with correlational analysis. The first research question was addressed descriptively, while the remaining questions were examined using correlational statistics, analysis of covariance (ANCOVA), and multiple regression. For the ANCOVA analyses, students were classified into above average, average, and below average groups based on Mathematics performance and reading-comprehension scores. The dependent variable was performance on the Genetics problem-solving test. The design was consistent with the source manuscript's objective of examining naturally occurring differences and relationships without manipulating the independent variables.

Research Locale

The study was conducted at Sergio Osmeña Sr. High School in Quezon City, where the researcher was teaching Science and Technology II (Biology). The school was located near Araneta Avenue and Del Monte Avenue and served learners from surrounding communities. Data collection for the main study was conducted during the fourth quarter of School Year 2012-2013, from January to March 2013.

Participants and Sampling Technique

Sixty second year high school students from three sections handled by the researcher were randomly selected as participants. The study involved 34 male students (56.67%) and 26 female students (43.33%), with ages ranging from 13 to 17 years. For the supplementary semi-structured interviews described in the thesis, stratified random sampling was used and every third name on the class record was selected, resulting in ten interviewees from each of three sections. The quantitative test results constituted the principal evidence reported in the Results and Discussion section.

Research Instrument

Three sources of performance data were used. Mathematics performance was represented by students' first-, second-, and third-quarter Mathematics grades. Reading comprehension was measured using a 50-item teacher-made test composed of ten science-related paragraphs with five multiple-choice questions per paragraph. Problem solving in Genetics was measured using a 50-item teacher-made multiple-choice test covering Mendelian and non-Mendelian inheritance, including monohybrid and dihybrid crosses, incomplete dominance, codominance, multiple alleles, sex-linked inheritance, and related probability applications.

The test instruments underwent expert review, content validation, pilot testing, and item analysis. Six expert validators from Biology and English evaluated consistency with content, language suitability, and appropriateness of the items. The initial Genetics test contained 100 items and was pilot-tested with 30 students; items were evaluated through difficulty and discrimination indices, and acceptable items were retained for the final instrument. Reliability was established through a test-retest procedure with 30 second year students who were not included in the final sample, using Spearman rank correlation. These procedures followed the source manuscript's stated principles for instrument development and validation (Gay & Airasian, 1992; Sevilla et al., 1992).

Data Gathering Procedure

Administrative permission was obtained from the Division of City Schools, Quezon City, and the principal of Sergio Osmeña Sr. High School before the pilot testing and main data collection. The reading-comprehension test was administered during the second week of January 2013 before the Genetics lessons and was allotted approximately 80 minutes. The Genetics problem-solving test was administered during the second week of March 2013 after instruction on Mendelian and non-Mendelian Genetics. The researcher retrieved the completed test papers, compiled students' profile and grade data, conducted the supplementary interviews described in the thesis, and submitted the quantitative data for statistical analysis.

Data Analysis

Frequency, percentage, mean, standard deviation, and coefficient of variation were used to describe Mathematics performance, reading comprehension, and Genetics problem-solving scores. ANCOVA was used to determine whether problem-solving performance differed when students were categorized according to Mathematics performance and reading comprehension, with Scheffé post hoc procedures used in the source analysis. Pearson r was used to examine the relationships among the three principal variables, and multiple regression was used to identify the best predictor of Genetics problem-solving skills. VassarStats statistical software was used in the original analysis, and the level of significance was set at .05.

Ethical Consideration

The source thesis documented formal administrative permission from the Division of City Schools and the school principal before testing and data gathering. The manuscript did not report a separate institutional ethics-board approval number or a detailed written consent and confidentiality protocol. Accordingly, this journal conversion does not claim procedures that were not documented in the original study.

RESULTS AND DISCUSSION

Mathematics Performance, Reading Comprehension, and Genetics Problem Solving

Students were evenly distributed across the above average, average, and below average performance groups (20 students per group). In Mathematics, the group means were 88.40, 81.60, and 75.20, respectively, with an overall mean of 81.73. Reading-comprehension means were 38.40, 29.95, and 20.25, with an overall mean of 29.53 as summarized in the thesis conclusion. Genetics problem-solving means were 38.50, 32.45, and 19.85, with an overall mean of 30.27. Across all three measures, higher-performing groups consistently obtained higher scores.

Table 1. *Summary of Student Performance by Group*

Measure	Above Average	Average	Below Average	Overall Mean
Mathematics performance	88.40	81.60	75.20	81.73
Reading comprehension	38.40	29.95	20.25	29.53
Problem solving in Genetics	38.50	32.45	19.85	30.27

The parallel ordering of group means suggests that Mathematics, reading comprehension, and Genetics problem solving were not independent classroom competencies. Students with stronger Mathematics performance and stronger comprehension also tended to perform better on the Genetics problems. This pattern is consistent with research showing that Genetics combines quantitative reasoning with technical language and representation (Bahar et al., 1999; Duncan & Reiser, 2007) and with studies linking reading comprehension to mathematical word-problem success (Fuchs & Fuchs, 2002; Pape, 2004).

Differences in Genetics Problem Solving by Mathematics and Reading Performance

ANCOVA results showed a statistically significant main effect of Mathematics performance on Genetics problem-solving scores, $F = 3.374163$, $p = .041475$. Reading comprehension also produced a statistically significant main effect, $F = 6.518109$, $p = .002882$. Thus, students categorized at higher levels of Mathematics performance and reading comprehension achieved higher Genetics problem-solving scores than students in lower performance groups.

Table 2. *ANCOVA Summary for Genetics Problem-Solving Performance*

Grouping Variable	SS	df	MS	F	p
Mathematics performance	220.0872	2	110.0436	3.374163	.041475
Reading comprehension	385.865	2	192.9325	6.518109	.002882

The mathematics result supports the view that the quantitative nature of Mendelian and non-Mendelian Genetics places demands on probability and symbolic reasoning. Stewart (1982, 1983) and Smith (1988) similarly described the importance of structured reasoning in Genetics problem solving. The stronger F value for reading comprehension also underscores that students must accurately interpret the words, conditions, and relationships in a Genetics problem before mathematical procedures can be successfully applied.

Relationships among Mathematics, Reading Comprehension, and Genetics Problem Solving

Pearson correlation analysis showed positive relationships among all three pairs of variables. Reading comprehension and Genetics problem solving had the strongest association ($r = .8132$), described in the thesis as a very high correlation. Mathematics performance correlated with reading comprehension at $r = .7477$ and with Genetics problem solving at $r = .7128$, both interpreted as moderately high correlations.

Table 3. *Correlations among the Study Variables*

Pair of Variables	r	Source Interpretation
Mathematics performance - Reading comprehension	.7477	Moderately high
Mathematics performance - Genetics problem solving	.7128	Moderately high
Reading comprehension - Genetics problem solving	.8132	Very high

The strongest correlation between reading comprehension and Genetics problem solving indicates that comprehension was closely linked to students' capacity to interpret and solve written Genetics tasks. This finding is consistent with Fuchs and Fuchs (2002), Jordan et al. (2002), and Bernardo (1999, 2005), whose work shows that language and reading processes can influence performance on quantitative word problems. In Genetics, the relationship is particularly plausible because learners must coordinate ordinary language, scientific terminology, and mathematical representations within the same problem situation.

Predictors of Problem-Solving Skills in Genetics

The multiple regression model reported $R^2 = .68983861$ and adjusted $R^2 = .65547631$, indicating that the set of predictors accounted for approximately 69% of the variance in Genetics problem-solving scores. Reading comprehension had the strongest coefficient and was statistically significant ($B = .621671$, standardized coefficient = .597598, $t = 4.846947$, $p = 1.07 \times 10^{-5}$). The coefficient table reported $p = .26067$ for Mathematics performance, $p = .705567$ for age, and $p = .454467$ for Biology performance.

Table 4. *Multiple Regression Analysis Predicting Genetics Problem-Solving Scores*

Predictor	Std. Coef.	B	SE B	t	p
Intercept		-17.6412	15.68858	-1.12446	.2657
Age	-0.02883	-0.27978	0.73669	-0.37979	.705567
Mathematics performance	0.167028	0.241876	0.212823	1.136511	.26067
Biology performance	0.116002	0.162353	0.215515	0.753326	.454467
Reading comprehension	0.597598	0.621671	0.12826	4.846947	1.07E-05

Model fit: $R^2 = .68983861$; adjusted $R^2 = .65547631$; Cohen's $f^2 = 2.0055$; standard error of estimate = 4.9510.

The thesis narrative described Mathematics and age as contributors to the regression model; however, the coefficient table itself reported p-values above .05 for Mathematics, age, and Biology performance. To preserve the original numerical evidence without adding unsupported significance claims, the present article treats reading comprehension as the statistically significant individual coefficient in the reported multivariable model while recognizing that Mathematics performance was significant in the ANCOVA and strongly related to problem solving at the bivariate level. Overall, the results support the study's central interpretation that reading comprehension was the strongest predictor of Genetics problem-solving performance.

CONCLUSION

The study showed that second year high school students' Mathematics performance, reading comprehension, and Genetics problem-solving skills moved in a consistent direction across performance groups. Students in the above average groups obtained the highest means, whereas students classified as below average obtained the lowest means. ANCOVA further established significant differences in Genetics problem-solving performance according to both Mathematics performance and reading comprehension, demonstrating that these competencies were meaningfully associated with students' success in solving Genetics problems.

All three major variables were positively correlated, and the strongest relationship was between reading comprehension and Genetics problem solving ($r = .8132$). The regression model explained approximately 69% of the variance in problem-solving scores, and reading comprehension emerged as the strongest statistically significant individual predictor in the reported coefficient table. The findings therefore support the conclusion that Genetics problem solving is an interdisciplinary literacy and numeracy task: mathematical competence is important, but learners must also understand the language, conditions, and scientific vocabulary embedded in Genetics problems before they can apply appropriate procedures.

Recommendation

Science and Mathematics teachers should strengthen explicit instruction in reading and interpreting technical problems, particularly the identification of relevant information, scientific vocabulary, quantitative relationships, and the meaning of symbols used in Genetics. Reading-comprehension activities may be integrated into Biology lessons, and students should be given repeated opportunities to explain how they interpreted a problem before performing calculations. School administrators and curriculum planners may likewise encourage cross-disciplinary coordination among English, Mathematics, and Science teachers so that comprehension and problem-solving strategies are reinforced across subject areas.

Future studies should replicate the research with larger and more diverse samples and may use specific tests of mathematical processes rather than quarterly grades alone. Longitudinal designs could examine how Mathematics and reading-comprehension differences develop before students encounter formal Genetics. Additional qualitative work, including systematic follow-up interviews, could identify which components of reading comprehension most strongly support Genetics problem solving and how students represent difficult problem situations.

Because the original problem-solving instrument focused on Mendelian and non-Mendelian Genetics, future researchers should extend the approach to other Biology and Science domains. Experimental or intervention studies are also needed to determine which instructional practices for reading, mathematical reasoning, self-assessment, and scientific problem solving produce the greatest improvement in learner performance.

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