Beyond Graduate Enrollment: Exploring the Relationships Between Motivation and Genetics Misconceptions Among In-Service Science Teachers

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ABSTRACT:

Background: Genetics misconceptions remain prevalent among science teachers despite advances in biological sciences, potentially affecting the quality of science instruction. At the same time, in-service teachers pursue graduate education for diverse intrinsic and extrinsic reasons that may influence their professional learning.

Objective: This study explored the relationship between graduate enrollment motivations and genetics misconceptions among in-service science teachers enrolled in the Master of Arts in Education major in General Science.

Methods: A convergent mixed-methods design was employed involving 18 graduate students. Quantitative data were collected using a researcher-developed Genetics Misconception Diagnostic Test and analyzed through descriptive statistics, while qualitative data from an open-ended questionnaire were analyzed using reflexive thematic analysis. Findings were integrated through narrative triangulation.

Results: High levels of misconceptions persisted, particularly regarding genetic determinism, gene function, genome organization, and gene–environment interaction. Participants' primary motivations for graduate enrollment included scientific knowledge acquisition, professional development, career advancement, teaching competence, and personal growth. The integration of findings indicated that teachers pursued graduate education not only for career progression but also to address gaps in their scientific understanding.

Conclusion: Graduate education serves as a transformative pathway that facilitates conceptual change, reduces genetics misconceptions, strengthens pedagogical content knowledge, and enhances science teaching practices, ultimately contributing to improved student scientific literacy.

Keywords: genetics misconceptions, graduate education, in-service science teachers, motivation, conceptual change

1. Introduction

The science of genetics gains world attention nowadays. Recent advances in molecular genetics, genomics, epigenetics, and biotechnology have transformed contemporary biological science and, consequently, the

expectations for science educators. Teachers are expected not only to possess accurate conceptual understanding of genetics but also to facilitate scientific literacy that enables learners to evaluate rapidly evolving issues such as gene editing, personalized medicine, genetic testing, and genetically modified organisms. Despite these developments, genetics remains one of the most conceptually difficult areas in biology, with misconceptions persisting across educational levels, including among preservice teachers, in-service teachers, and graduate students (Gericke et al., 2022; Duncan et al., 2023).

Misconceptions are deeply rooted cognitive structures that conflict with accepted scientific explanations and often resist conventional instruction (Sinatra & Chinn, 2023). In genetics education, misconceptions commonly involve genetic determinism, the role of genes and environment in phenotype expression, mutation, inheritance, genome organization, and biotechnology (Lewis & Wood-Robinson, 2022). Such misconceptions are particularly concerning among graduate students preparing to become science educators because inaccurate conceptions may subsequently be transferred to their future learners, thereby perpetuating scientific misunderstandings across generations.

Contemporary science education research emphasizes that conceptual change requires learners to reconstruct existing knowledge rather than merely accumulate new information (Pugh et al., 2023). Consequently, identifying misconceptions among graduate students provides valuable evidence for improving graduate biology curricula, designing conceptual change interventions, and strengthening teacher education programs. Diagnostic assessment has therefore become an essential component of biology education because it allows instructors to identify persistent misconceptions before they become entrenched in classroom practice (Acarli, 2025).

While misconceptions have received considerable attention in biology education, considerably less research has investigated the motivations that drive science teachers to pursue graduate education and whether these motivations provide meaningful context for understanding conceptual development. Graduate students often enroll in master's programs because of a combination of intrinsic motivations—including intellectual curiosity, mastery of disciplinary knowledge, and personal growth—and extrinsic motivations such as promotion, professional advancement, salary progression, and employment opportunities (Braun & Clarke, 2022; Deci & Ryan, 2020). These motivations may influence students' engagement with graduate coursework, learning strategies, and willingness to reconstruct prior conceptions.

Understanding graduate students' motivations is particularly important within science teacher education because professional advancement does not necessarily guarantee conceptual mastery. Individuals primarily motivated by credential acquisition may engage differently with advanced scientific content than those driven by knowledge acquisition or professional competence. Consequently, examining motivations alongside misconceptions offers a more comprehensive understanding of graduate learning than investigating either construct independently.

The present study addresses this gap by integrating quantitative evidence on genetics misconceptions with qualitative evidence regarding the reasons graduate students pursue the Master of Arts in Education major in General Science. Specifically, the study determined the prevalence of genetics misconceptions among graduate students enrolled in Advanced Biology while simultaneously exploring the motivations underlying their enrollment in graduate education. The integration of these complementary datasets provides a richer understanding of graduate science learning and offers implications for curriculum development, conceptual change instruction, and graduate teacher education.

Specifically, this study sought to answer the following questions:

1. What genetics misconceptions are prevalent among Master of Arts in Education students majoring in General Science?

2. What are the primary reasons that motivate graduate students to pursue the Master of Arts in Education program?

3. What implications do graduate students' motivations and conceptual understanding have for improving graduate science teacher education?

The findings are expected to contribute to biology education by informing graduate curriculum enhancement, conceptual change pedagogy, and professional development initiatives that promote scientifically accurate understanding among future science educators.

2. Methodology

Research Design

This study employed a convergent mixed-methods research design, in which quantitative and qualitative data were collected during the same period analyzed independently, and integrated during interpretation to obtain a comprehensive understanding of graduate students' conceptual understanding and motivations for pursuing graduate education (Creswell & Plano Clark, 2018). The quantitative component determined the prevalence of genetics misconceptions, whereas the qualitative component explored participants' reasons for enrolling in the Master of Arts in Education major in General Sciences program.

Participants

The participants consisted of 18 graduate students enrolled in the Master of Arts in Education (MAEd) major in General Science taking Advanced Biology at a state university in the Philippines. Participants were selected through total enumeration because all students enrolled in the course participated in the study.

Research Instruments

Two instruments were utilized. The first was a researcher-developed Genetics Misconception Diagnostic Test consisting of fifteen misconception statements representing major genetics concepts, including gene function, genetic determinism, genome organization, mutation, inheritance, biotechnology, and gene–environment interaction. Participants responded by identifying whether each statement was scientifically correct or incorrect. Incorrect responses indicated the presence of misconceptions.

The second instrument consisted of one open-ended question asking participants to describe their primary reason(s) for enrolling in the Master of Arts in Education program. This item generated qualitative responses used for thematic analysis.

Prior to administration, the misconception instrument underwent expert validation by biology educators and science education specialists to establish content validity. Internal consistency reliability was evaluated using the Kuder–Richardson Formula 20 (KR-20), which is appropriate for dichotomously scored items.

Data Collection

Following institutional approval and participants' informed consent, the misconception diagnostic test and the open-ended questionnaire were administered during the Advanced Biology course. Participation was voluntary, confidentiality was maintained, and no identifying information was included in the analysis.

Data Analysis

Quantitative data were analyzed using descriptive statistics, including frequency counts, percentages, and misconception prevalence for each item. Misconception prevalence was interpreted using qualitative descriptors ranging from Very Low to Very High based on the proportion of incorrect responses.

Qualitative responses were analyzed through reflexive thematic analysis following the six-step framework proposed by Braun and Clarke (2022): familiarization with the data, generation of initial codes, theme development, theme review, theme definition and naming, and report preparation.

Emergent themes represented the dominant motivations for graduate enrollment.

Findings from both datasets were integrated through narrative triangulation to determine how graduate students' motivations provide context for interpreting the persistence of genetics misconceptions and to derive implications for graduate science teacher education.

Ethical Considerations

Ethical standards for educational research were observed throughout the study. Participation was voluntary, informed consent was obtained from all participants, responses were treated confidentially, and the results were reported only in aggregate form to protect participants' identities.

3. Results and Discussion

To establish the extent of conceptual understanding among the participants, the study first examined the prevalence of genetics misconceptions held by in-service science teachers enrolled in the Master of Arts in Education major in General Science. Identifying these misconceptions provides valuable insights into the specific genetics concepts that remain problematic despite participants' professional teaching experience and graduate-level studies. The findings presented in **Table 1** summarize the frequency, percentage, and level of prevalence of misconceptions across fifteen key genetics concepts, serving as a basis for identifying areas requiring conceptual change and curriculum enhancement.

Table 1 Prevalence of Genetics Misconceptions among Graduate Students (N = 18)

Misconception	Correct	Incorrect	Misconception (%)	Interpretation
Each gene controls only one specific trait	3	15	83.3	Very High
Genes alone determine all characteristics	2	16	88.9	Very High
Genetic makeup completely determines who a person is	1	17	94.4	Very High
Genes and environment act independently	3	15	83.3	Very High
Genes completely determine future outcomes	15	3	16.7	Very Low
Genetic modification inevitably produces harmful organisms	12	6	33.3	Low
All mutations are harmful	16	2	11.1	Very Low
Humans possess more genes than any other species	11	7	38.9	Low
All DNA consists only of protein-coding genes	2	16	88.9	Very High
Genetic testing predicts everything	9	9	50.0	Moderate
All genetic disorders are inherited	4	14	77.8	High
Identical twins are completely identical	13	5	27.8	Low
Genetic engineering is inherently unethical	1	17	94.4	Very High
Genetic testing is completely accurate	10	8	44.4	Moderate
Genetics justifies eugenics and discrimination	12	6	33.3	Low

The findings indicate that misconceptions remain prevalent even among graduate students enrolled in an Advanced Biology course. Six misconceptions were classified as Very High, one as High, two as Moderate, four as Low, and two as Very Low.

The most prevalent misconceptions were:

1. An individual's genetic makeup completely determines who they are (94.4%)
2. Genetic engineering is inherently unethical or unacceptable (94.4%)
3. Genes alone determine all characteristics (88.9%)
4. All DNA consists only of protein-coding genes (88.9%)
5. Each gene controls only one specific trait (83.3%)
6. Genes and environmental factors do not interact (83.3%)

These results reveal that misconceptions associated with genetic determinism, gene function, and gene–environment interaction remain widespread despite participants' enrollment in graduate-level biology.

Persistence of Genetic Determinism

The most striking finding was the high prevalence of misconceptions related to genetic determinism. Nearly all participants believed that genetic makeup completely determines personal characteristics (94.4%), while 88.9% believed genes alone determine all traits.

These findings suggest that participants continue to conceptualize genes as autonomous determinants rather than recognizing that phenotypes emerge from complex interactions among genes, epigenetic regulation, developmental processes, and environmental influences. Contemporary genetics emphasizes that most complex traits—including intelligence, behavior, and disease susceptibility—result from multifactorial interactions rather than single-gene control.

The persistence of genetic determinism among graduate students is concerning because these future science educators may inadvertently transmit oversimplified genetic concepts to their own students.

Misconceptions Regarding Gene Function

Another major misconception involved the belief that each gene controls only one specific trait (83.3%). Modern molecular genetics has demonstrated that genes frequently exhibit pleiotropy, wherein a single gene influences multiple phenotypic traits. Conversely, most observable characteristics are polygenic, involving the coordinated action of numerous genes. The persistence of this misconception indicates reliance on simplified Mendelian examples without sufficient exposure to post-genomic concepts.

Limited Understanding of Genome Organization

Approximately 89% believed that all DNA consists only of protein-coding genes. This misconception suggests inadequate understanding of genome organization. The human genome contains substantial amounts of non-coding DNA involved in gene regulation, chromosomal stability, RNA production, and other biological functions. Advances from genomic research have fundamentally changed traditional views that equate DNA solely with genes.

Gene–Environment Interaction

More than four-fifths of participants believed genetic and environmental factors function independently.

Current biological research demonstrates continuous interactions between genes and environmental influences through epigenetic regulation, gene expression, nutrition, stress, and developmental plasticity. Failure to appreciate these interactions may lead to deterministic interpretations of human health and behavior.

Biotechnology and Ethical Misconceptions

Nearly all respondents believed that genetic engineering is inherently unethical or unacceptable. This finding likely reflects the influence of ethical controversies presented in

public discourse rather than scientific evidence. Modern biotechnology encompasses numerous applications—including insulin production, genetically modified crops, and gene therapy—that provide substantial societal benefits when conducted within ethical and regulatory frameworks.

Graduate biology courses should therefore distinguish scientific principles from ethical, legal, and social considerations.

To complement the quantitative findings on genetics misconceptions, the study explored the motivations that influenced in-service science teachers to pursue graduate education. Understanding these motivations provides valuable context for interpreting participants' commitment to professional learning and conceptual development. **Table 2** presents the emergent themes derived from the thematic analysis of participants' responses, highlighting both intrinsic and extrinsic factors that motivated their enrollment in the Master of Arts in Education Major in General Science**.**

Table 2. Emergent Themes on the Reasons for Pursuing the Master of Arts in Education Major in General Science

Theme	Representative Responses	Frequency (n = 28)	Percentage
1. Professional Development and Career Advancement	"To develop myself professionally"; "Professional growth"; "Develop my professional and teaching skills"; "Enhance my teaching"; "Learn advanced skills for the current profession."	8	28.6%
2. Acquisition and Mastery of Scientific Knowledge	"To learn and master my major"; "Gain more knowledge"; "Upgrade my understanding about Science Education"; "Learn more about science"; "Further study in my major."	10	35.7%
3. Promotion and Employment Opportunities	"For promotion"; "Need for applying in DepEd"; "Pass the RQA"; "Earn master's units for item and RQA."	6	21.4%
4. Improvement of Teaching Competence	"Develop my teaching skills"; "Enhance my teaching"; "Impart more knowledge to future students"; "Improve my teaching in science."	3	10.7%
5. Personal Growth and Self-Fulfillment	"Fulfill a personal challenge"; "Assess myself"; "Opportunity for intellectual growth."	3	10.7%

Note. Some responses reflected more than one motivation and were coded under multiple themes where appropriate.

Thematic analysis revealed five major motivations influencing graduate students' decision to pursue the Master of Arts in Education major in General Sciences. The most frequently occurring theme was Acquisition and Mastery of Scientific Knowledge (35.7%), followed by Professional Development and Career Advancement (28.6%). Participants consistently expressed a desire to deepen their understanding of science, master their field of specialization, and expand their disciplinary knowledge.

The second dominant theme, Professional Development and Career Advancement, reflected participants' aspirations to enhance their professional competencies, improve their instructional practices, and become more effective science educators. Several respondents viewed graduate education as an avenue for strengthening their pedagogical and professional skills.

Another notable theme was Promotion and Employment Opportunities (21.4%). Many participants explicitly mentioned obtaining master's units to qualify for promotion, meet the requirements of the Registry of Qualified Applicants (RQA), or improve their employment prospects within the Department of Education. These findings suggest that institutional policies and career advancement opportunities serve as significant extrinsic motivators for graduate study.

Although less frequently mentioned, Improvement of Teaching Competence (10.7%) emerged as another important motivation. Participants emphasized their desire to improve science instruction and acquire new teaching strategies that could benefit their future students.

Finally, Personal Growth and Self-Fulfillment (10.7%) reflected intrinsic motivations such as intellectual curiosity, self-assessment, and personal accomplishment. Respondents viewed graduate education as an opportunity to challenge themselves academically and achieve personal fulfilment beyond career-related objectives.

Collectively, these findings indicate that graduate students' motivations encompass both intrinsic factors, including intellectual growth and mastery of scientific knowledge, and extrinsic factors, such as career advancement, promotion, and employment opportunities. This combination of motivations highlights the multifaceted nature of graduate education among science teachers.

Viewed together, the qualitative and quantitative findings reveal an important educational phenomenon. The teachers' strong motivation to pursue graduate education for content mastery appears to be justified by the substantial misconceptions identified in genetics. Rather than representing contradictory findings, the two datasets complement one another. Teachers sought advanced education precisely because they perceived deficiencies in their disciplinary knowledge, while the misconception assessment objectively confirmed that significant conceptual gaps still existed. This convergence strengthens the argument that graduate education serves as an important mechanism for addressing deficiencies in teachers' content knowledge rather than merely providing credentials for promotion.

The findings also demonstrate that motivations for graduate education extend beyond career advancement. Although promotion and employment opportunities accounted for approximately one-fifth of the responses, the majority of participants emphasized professional growth, improved teaching competence, and acquisition of scientific knowledge. These intrinsic motivations are encouraging because previous research has demonstrated that teachers who value professional learning are more likely to modify their instructional beliefs and develop stronger pedagogical self-efficacy than those motivated primarily by external incentives (Lowell & McNeill, 2023; Preminger et al., 2024).

Nevertheless, the persistence of misconceptions despite these motivations suggests that simply enrolling in graduate school is insufficient for conceptual change. Conceptual change theory argues that misconceptions are resistant because learners interpret new information through existing cognitive frameworks. Consequently, effective graduate instruction should deliberately challenge inaccurate prior conceptions through inquiry-based learning, diagnostic assessment, conceptual conflict strategies, and reflective discourse rather than relying primarily on lectures or content transmission (Sinatra & Chinn, 2011; Braun & Clarke, 2022). Likewise, science teacher professional development has been shown to be most effective when it explicitly connects disciplinary content, pedagogical reasoning, and classroom practice over sustained periods of learning (Lowell & McNeill, 2023).

An important implication of the present study is that graduate programs should not be viewed

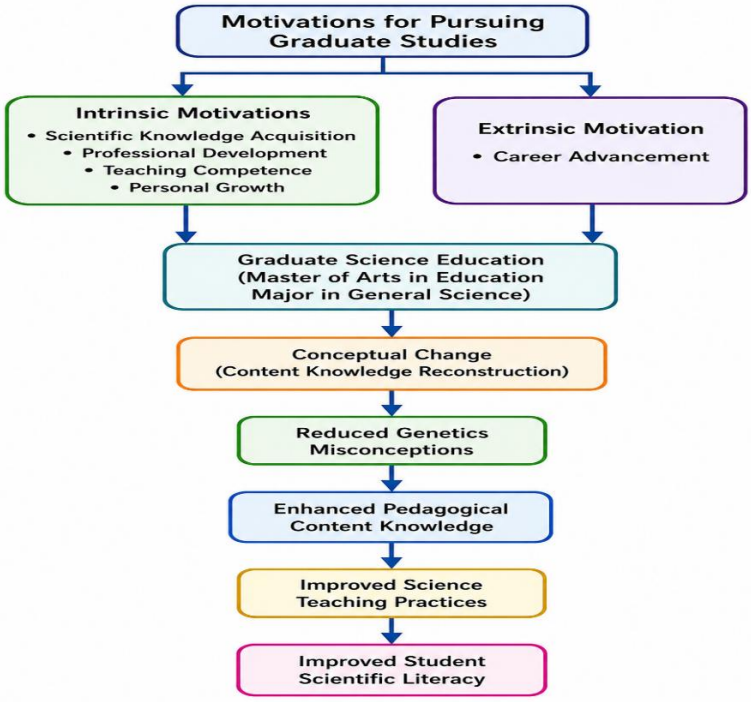
solely as avenues for salary advancement or promotion. Instead, they should function as opportunities for rebuilding teachers' conceptual understanding of science. Picardal and Picardal (2023) found that science teachers who pursued advanced studies because of inadequate content knowledge gradually reconstructed their understanding through sustained professional learning and content enrichment. Similarly, the present findings suggest that graduate curricula should emphasize conceptual understanding of modern genetics, including gene regulation, epigenetics, systems biology, and gene–environment interactions, because these were the areas in which misconceptions remained most prevalent.

Overall, integrating the quantitative and qualitative findings supports a broader conclusion: science teachers pursue graduate education not merely to obtain promotion but because they recognize the necessity of strengthening their disciplinary competence. The persistence of genetics misconceptions demonstrates that this need is genuine, reinforcing the importance of graduate education as a vehicle for professional growth, conceptual change, and improved science teaching. Graduate programs that intentionally integrate contemporary biological content with evidence-based pedagogical approaches are therefore likely to contribute not only to teachers' professional advancement but also to improved scientific literacy among the students they eventually teach.

Conceptual Model Emerging from the Study

The integration of the quantitative and qualitative findings enabled the development of a conceptual framework that illustrates the relationship between graduate enrollment motivations and the reduction of genetics misconceptions among in-service science teachers. **Figure 1** presents the proposed pathway, demonstrating how intrinsic and extrinsic motivations facilitate conceptual change, strengthen pedagogical content knowledge, and ultimately contribute to improved science teaching practices and student scientific literacy.

Figure 1 Conceptual Model Emerging from the Study



The emerging conceptual framework summarizes the study by illustrating how intrinsic and extrinsic motivations encourage in-service science teachers to pursue the Master of Arts in Education Major in General Science. Through graduate education, teachers experience conceptual change that reduces genetics misconceptions, strengthens pedagogical content knowledge, and improves science teaching practices. Ultimately, the framework emphasizes that graduate education is not merely a pathway to career development but a transformative process that enhances teacher's scientific understanding and contributes to improved student scientific literacy.

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