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Research Article

Affective disposition and academic outcome: A correlational study of pre-service teachers' genetics performance

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ABSTRACT

This correlational study examines the relationship between pre-service teachers' affective dispositions towards genetics and their academic performance in genetics courses. The unit of analysis consists of 101 undergraduate pre-service science teachers enrolled in a public university. A descriptive correlational research design was employed to quantify the nature and strength of the association between variables. Data were collected through standardized assessments of genetic content knowledge and a 5-point Likert-scale questionnaire measuring perceptions and attitudes towards genetics. The reliability of the instruments was confirmed using Cronbach's alpha, with perception and attitude scales achieving coefficients of 0.87 and 0.85, respectively. Data analysis involved the use of Pearson's correlation coefficient to determine the strength and direction of relationships, complemented by multiple Linear regression analysis to identify the predictive power of affective dispositions on academic outcomes. The results indicated that only 5% of students' perception and attitude was able to predict their performance with a p-value of 0.087 depicting the model's insignificance at 0.05 significance level, despite the positive attitude (mean [M] = 3.95) and perception (M = 4.09). This highlight's the gap between students' affective dispositions and their academic performance as what one might perceive may not entirely reflect within the shortest possible time. The study's findings further suggest that tailored instructional strategies focusing on affective factors can enhance genetics comprehension and teaching efficacy among pre-service teachers.

Keywords: academic performance, attitude, genetics, perception, pre-service teachers

INTRODUCTION

A fundamental component of biological sciences, genetics provides information on diversity, heredity, and the molecular processes underlying life. Its importance transcends academia, impacting developments in biotechnology, agriculture, and medicine. Because they will influence how future generations perceive these ideas, science educators; especially pre-service teachers, need to have a solid grasp of genetics (Duncan et al., 2007; Shea et al., 2015). Genetics is frequently seen as a difficult subject to teach and study, despite its significance (Kampourakis et al., 2014). Pre-service science teachers frequently encounter difficulties in grasping complex genetic concepts, which can impact their confidence and effectiveness in the classroom (Kampourakis et al., 2014). Research has indicated that the attitudes and views of pre-service teachers regarding genetics have a substantial impact on their learning results and intents to teach (Boerwinkel et al., 2014).

Additionally, the construct of science disposition learners' enduring tendencies to engage with science through curiosity, persistence, and reflective thinking matters because it shapes how pre-service teachers approach demanding content such as genetics and how they later teach it (Osborne & Dillon, 2008; Van Aalderen-Smeets et al., 2012). In Ghana, the challenge is not only attitudinal; constraints in teaching and learning resources and uneven access to practical activities can limit opportunities for deep engagement with biology ideas, including genetics, even when learners report positive orientations toward science (Amoah et al., 2023). Recent work also shows that teacher candidates' dispositions and intentions to teach genetics can be shaped by perceived usefulness, attitudes, and social influence around innovative tools, including artificial intelligence (AI)-supported tutoring systems (Adelana et al., 2024).

Nevertheless, teacher education programs still face persistent difficulties in ensuring that pre-service science teachers develop the conceptual foundations, confidence, and pedagogical strategies needed for abstract topics such as genetics. Evidence from Ghanaian secondary biology contexts indicates that limited instructional materials and restricted practical experiences can undermine effective biology teaching and learning (Amoah et al., 2023). Internationally, research continues to document that genetics remains

conceptually challenging and that improving learning often requires purposeful instructional designs that target misconceptions and promote conceptual change (Lewis & Kattmann, 2004; Pacaci et al., 2023).

1. What is the perception of pre-service science teachers towards the study of genetics?
2. What is the attitude of pre-service science teachers towards the study of genetics?
3. What is the association between pre-service science teachers' perception, attitude and their performance in genetics?

THEORETICAL FRAMEWORK ON TEACHER DISPOSITION AND LEARNING

In educational research, especially in science education, it is essential to comprehend the theoretical underpinnings that explain how learners' dispositions affect academic success. According to Ritchhart (2002), disposition describes a person's propensities or attitudes toward learning, such as curiosity, accountability, open-mindedness, and perseverance. Constructivism and the theory of planned behavior (TPB), two important theoretical frameworks that shed light on the role of disposition in learning, particularly in science fields like genetics, are the main topics of this study.

Constructivism and Disposition in Learning

According to the learning theory known as constructivism, students actively create knowledge by experiences and introspection (Piaget, 1972; Vygotsky, 1978). It highlights how learners' attitudes, beliefs, and past knowledge are all important components of the learning process, having a significant impact on how they process new information. Piaget's theory of cognitive development states that students use preexisting cognitive structures to absorb or accommodate new information. How well a learner integrates new information depends on their disposition, which includes their willingness to interact with and consider novel ideas (Piaget, 1972). By proposing the idea of the zone of proximal development (ZPD), where learning happens most efficiently with the right scaffolding, Vygotsky (1978) expanded on this perspective. The learner's disposition towards seeking help, collaborating, and reflecting becomes central to their progress within the ZPD.

Constructivism emphasizes the value of experiential, inquiry-based, and student-centered learning in science education. These methods work best when students have good learning dispositions like curiosity and self-control (Fosnot & Perry, 2005). For instance, while teaching genetics, pre-service teachers who have a strong scientific tendency are more likely to use reflective practices and conceptual transformation techniques (Kind, 2009).

Theory of Planned Behavior and Learning Disposition

TPB, developed by Ajzen (1991), explains how behavioral intentions are formed and influenced by three key components: attitude toward the behavior, subjective norms, and perceived behavioral control. TPB is particularly useful in understanding pre-service teachers' disposition toward teaching and learning science.

In educational contexts, TPB helps predict behaviors such as pre-service teachers' intention to adopt inquiry-based practices, use laboratory experiments, or invest time in difficult subjects like genetics (Yilmaz & Sahin, 2011). A teacher with a favorable attitude toward science, high self-efficacy, and positive reinforcement from peers is more likely to exhibit constructive learning behaviors and dispositions. Modern educational models increasingly recognize disposition as a mediating factor in learning. For example, the dispositional learning theory developed by Costa and Kallick (2000) identifies "habits of mind" such as persistence, managing impulsivity, and thinking flexibly as critical to academic success. These habits align with both constructivist principles and TPB. Similarly, reflective practice models (e.g., Schön, 1983) emphasize the importance of disposition in teacher learning and professional development.

Conceptual Framework For the Study

This study is based on the idea that pre-service science teachers' science disposition especially their perception and attitude can shape the quality of their engagement with genetics content and, in turn, their academic outcomes. From a constructivist perspective, learners actively build meaning from prior knowledge and experiences, so perceptions of relevance and comprehensibility can influence willingness to invest effort in reorganizing ideas about inheritance (Fosnot & Perry, 2005). Recent evidence suggests that where students hold negative perceptions of genetics and persist with misconceptions, conceptual understanding and performance can remain low, reinforcing avoidance and surface learning (Ojo, 2024). Conversely, when genetics examples are made meaningful through appropriate representations and contexts, learners' reasoning and transfer can improve (Menendez et al., 2024).

TPB (Ajzen, 1991) offers a psychological explanation of behavior, positing that attitude toward a behavior, subjective norms, and perceived behavioral control collectively influence behavioral intention and performance. In the academic context, pre-service teachers' positive attitudes toward genetics and their perceived competence can drive their intention to learn, teach, and succeed in the subject (Opara et al., 2022) (**Figure 1**).

Conceptual Understanding and Challenges in Learning Genetics

Genetics is widely recognized as a foundational yet difficult domain in biology because many core ideas (e.g., gene, allele, chromosome distinctions, meiosis, inheritance probability, and gene environment interactions) are abstract and span multiple levels of organization. Contemporary studies continue to report persistent misconceptions in genetics and related biology topics, often linked to decontextualized instruction, symbolic difficulties, and fragmented curricula (Machová & Ehler, 2023; Ojo, 2024). Broader reviews similarly show that misconceptions in biology genetics included are global and resistant to change when teaching remains predominantly transmissive, underscoring the need for diagnostic assessment and targeted interventions (Guerra-

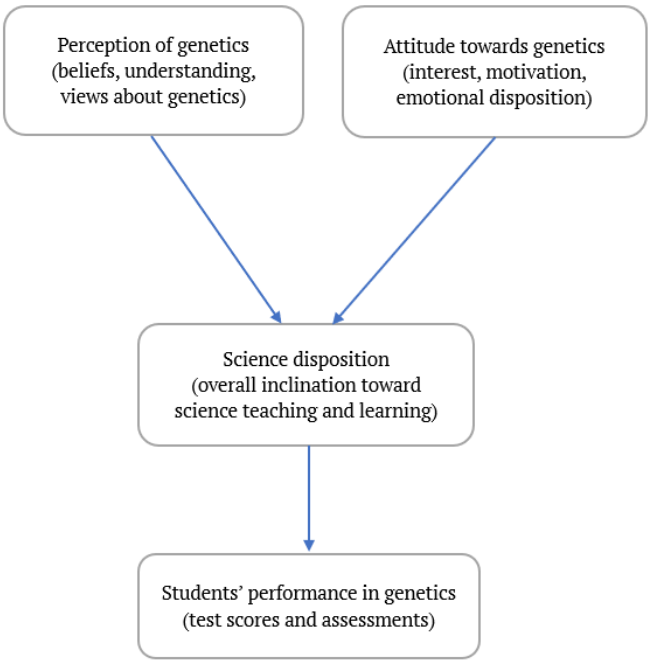

Figure 1. Conceptual framework (Source: Authors' own elaboration)

Reyes et al., 2024; Herak et al., 2025). Because genetics understanding depends heavily on modelling and representation, the design of visual and symbolic supports (e.g., pedigrees and diagrams) also matters; recent evidence indicates that well-designed visual representations can improve learning and transfer in inheritance reasoning, especially in online lessons (Menendez et al., 2024).

Given these challenges, recent evidence supports instructional approaches that explicitly confront misconceptions and promote conceptual restructuring. A large meta-analysis synthesising 218 studies shows that conceptual change strategies (e.g., cognitive conflict, cognitive bridging, and ontological category shift) have a large positive effect on science achievement, suggesting strong potential for addressing entrenched misconceptions in topics such as genetics (Pacaci et al., 2023). At the classroom level, active-learning designs can also support affect and understanding; for example, task-based learning has been shown to improve students' conceptual understanding of Mendelian genetics while reducing anxiety and increasing perceived competence during tasks (Borja & Mutya, 2024). For teacher preparation, emerging work also highlights the promise of technology-enhanced supports such as AI intelligent tutoring systems for building pre-service teachers' intentions and readiness to teach genetics, although social norms and perceived usefulness remain key drivers of adoption (Adelana et al., 2024).

Perception of Pre-Service Science Teachers Toward Biology and Genetics

Understanding how pre-service teachers perceive genetics is important because perceptions of relevance, difficulty, and usefulness influence engagement, help-seeking, and the depth of processing applied to complex biological explanations (Kind & Osborne, 2017). Recent mixed-method evidence with senior secondary students found that negative perceptions of genetics can coexist with high levels of misconceptions, suggesting that perceived difficulty and confusion can discourage sustained learning (Ojo, 2024). In teacher education, perceptions are also shaped by the learning environment; limited instructional materials, restricted laboratory opportunities, and inadequate learning resources can reduce perceived attainability of biology topics and weaken meaningful connections to practice (Amoah et al., 2023).

Studies continue to show that many pre-service teachers struggle to connect genetics ideas to real-world phenomena, which can make genetics seem conceptually remote and cognitively demanding (Krell & Krüger, 2022). Where genetics is presented mainly as terminology and routine problem sets, learners may recognize its importance yet still find it hard to integrate concepts into coherent explanatory models an issue linked to persistent misconceptions and limited conceptual transfer (Machová & Ehler, 2023; Menendez et al., 2024).

1. Key factors reported in the literature that shape pre-service teachers' perceptions of genetics include:
   (a) prior learning experiences, where earlier difficulties or uninspiring instruction can foster avoidance,
   (b) curriculum sequencing and fragmentation, which can obscure connections across molecular, cellular, and organismal levels, and
   (c) availability of learning supports such as laboratories, models, and high-quality materials (Amoah et al., 2023; Tsui & Treagust, 2013).
2. When genetics instruction does not explicitly elicit and address misconceptions, students may retain intuitive but scientifically inaccurate ideas about inheritance and trait expression, even after formal coursework (Lewis & Kattmann, 2004; Ojo, 2024). Conceptual change-oriented instruction, therefore, remains central for improving both understanding and confidence in discussing genetics (Pacaci et al., 2023).

Unfavorable perceptions have practical consequences: pre-service teachers may allocate less instructional time to genetics, rely on rote teaching, or avoid challenging topics, which can perpetuate learners' misconceptions and weaken genetics literacy (Machová & Ehler, 2023). In contrast, positive perceptions that emphasize relevance to health, biotechnology, and everyday decision-making can motivate the use of student-centered approaches and multiple representations (Menendez et al., 2024).

Perceptions may also be influenced by cultural and ethical dimensions of genetics (e.g., discussions of genetic disorders, heredity, and modern biotechnology). In Ghana, evidence suggests that cultural beliefs and prior knowledge can shape how pre-service biology teachers interpret genetics-related conditions, highlighting the value of culturally responsive resources and discussion-based pedagogies (Antwi, 2021).

Attitudes of Pre-Service Science Teachers Toward Biology Learning and Genetics

Attitude refers to learners' evaluative orientation toward a subject what they believe about it, how they feel about it, and what they intend to do with it (Ajzen, 1991). For genetics,

attitudes are shaped by perceived relevance and by the extent to which learners feel capable of reasoning with representations such as pedigrees, probability, and molecular models (Menendez et al., 2024). Recent findings in secondary contexts show that negative attitudes and perceptions can accompany high rates of misconceptions, which may reduce motivation and persistence when learners encounter difficult genetics ideas (Ojo, 2024).

Among teacher candidates, attitudes matter because they are linked to intentions and future teaching choices. Using the TPB, recent research with pre-service biology teachers found that attitudes and subjective norms can significantly predict intentions to teach genetics with AI tutoring systems, suggesting that social influence and perceived benefit shape willingness to adopt innovative supports (Adelana et al., 2024).

However, positive attitudes alone do not guarantee high performance in genetics, particularly when misconceptions and representational difficulties remain unaddressed. Evidence from active learning interventions indicates that engaging tasks can improve conceptual understanding and reduce anxiety, supporting both cognitive and affective development in genetics learning (Borja & Mutya, 2024). More broadly, conceptual change strategies have strong effects on achievement across science topics, reinforcing the importance of instruction that deliberately targets learners' prior ideas and reasoning patterns (Pacaci et al., 2023).

The Role of Science Disposition in Academic Performance

Science disposition captures relatively stable tendencies such as curiosity, perseverance, and openness to evidence that shape how learners approach scientific ideas and challenges (Van Aalderen-Smeets et al., 2012). In genetics learning, disposition can influence whether students persist through cognitive conflict, seek clarification, and engage in model-based reasoning rather than memorization (Kind & Osborne, 2017).

Yet recent reviews also highlight that misconceptions can persist even among motivated learners when instruction remains decontextualized or overly transmissive, implying that dispositions need to be supported by effective pedagogy, materials, and feedback (Guerra-Reyes et al., 2024; Herak et al., 2025). The implication for teacher education is that strengthening science disposition should be paired with explicit conceptual change teaching, diagnostic assessment, and representational supports to translate positive orientations into improved genetics understanding and performance (Pacaci et al., 2023; Menendez et al., 2024).

METHODOLOGY

This study adopted a descriptive correlational research design to examine the relationship between pre-service science teachers' perceptions, attitudes, and their performance in genetics. The study was grounded in the positivist paradigm, which emphasized objectivity, measurement, and quantification of variables. The participants in this study were 101 undergraduate students enrolled in genetics course in a large public university in Ghana. This course is part of the core curriculum and fulfills the Bachelor of Science requirement for all undergraduate science students.

Table 1. Reliability analysis summary (Cronbach's alpha)

Scale	Number of items	Cronbach's alpha
Perception on genetics	10	0.87
Attitude towards genetics	10	0.92

Table 2. 5-point scale interpretation

Scale	Responses
1.00-1.79	Strongly disagree
1.80-2.59	Disagree
2.60-3.39	Neutral
3.40-4.19	Agree
4.20-5.00	Strongly agree

Research Instrument

A standardized test was used to assess students' performance in genetics. Also, a closed end questionnaire was used to assess their perception and attitude towards the study of genetics. It consisted of 20 items; 10 each on perception and attitudes on a 5-point Likert scale. The reliability of the questionnaire was accessed using Cronbach's alpha (α) (**Table 1**).

The Cronbach's alpha value measures the internal consistency. The perception scale showed good internal consistency (α = .87), as did the attitude (α = .92) with an excellent internal consistency. This value, according to Pallant (2011) indicates a preferrable internal consistency of the questionnaires. This suggests that our instrument was highly reliable and a good assessor of pre-service students' perception and attitude.

Data Analysis

Data was analyzed using descriptive statistics (means [Ms] and standard deviation [SD]) to summarize perceptions and attitudes for research question 1 and research question 2. A multiple linear regression analysis was employed to investigate the relationship between perceptions, attitudes, and performance in genetics. Statistical significance was considered at a p-value of less than 0.05.

RESULTS

What Is the Perception of Pre-Service Science Teachers Towards the Study of Genetics?

A descriptive statistic (M and SD) was conducted to examine the perception of pre-service science teachers towards the study of genetics.

Following common practice (Sullivan & Artino, 2013; Yin et al., 2016) and supported in survey analysis literature, means are interpreted on a 5-point scale as represented in **Table 2**, with SD used to indicate response consistency; lower SD (< 0.50) reflects stronger agreement whiles a higher SD (> 0.50) also reflects lower agreement or highly varied responses. Although individual Likert items are ordinal, aggregates are treated as approximating interval data for descriptive and inferential purposes.

Table 3. Table on top of a page

Statements	M	SD
Genetics is a fundamental topic in understanding modern biology.	4.27	0.9
Knowledge of genetics is essential for solving real-world biological problems.	4.31	0.66
I believe genetics has a significant impact on everyday life.	4.25	0.67
Genetics is closely related to many scientific and medical breakthroughs.	4.24	0.67
Understanding genetics helps in making informed decisions about health.	4.27	0.68
Genetics is a simple subject that is easy to relate to real life.	3.56	1.07
The concepts in genetics are relevant to my future teaching career.	3.96	0.93
Advances in genetics influence ethical and social issues that should be discussed in schools.	3.84	0.96
I perceive genetics as a rapidly evolving and important scientific field.	4.13	0.78
Genetics education is crucial for raising scientifically literate citizens.	4.03	0.88
Overall	**4.09**	**0.82**

Table 4. Table on top of a page

Statements	M	SD
I enjoy learning about genetics.	3.87	0.98
Genetics is one of my favorite science topics.	3.64	1.08
I feel motivated to learn more about genetics beyond the classroom.	3.86	0.99
I am interested in how genetics can be applied in real-life situations.	4.20	0.72
I think genetics should be emphasized more in science curricula.	4.08	0.91
I find genetics to be an interested subject.	4.01	0.87
I feel confident discussing genetic topics with others.	3.85	0.99
I am curious about new discoveries in genetics.	3.87	0.90
I would choose to attend a workshop or seminar on genetics if given the opportunity.	4.06	0.90
Learning about genetics makes science more exciting to me.	4.02	0.96
Overall	**3.95**	**0.93**

Table 3 presents the perceptions of pre-service science teachers toward the study of genetics based on their responses to a series of statements rated on a 5-point Likert scale. The overall M score of 4.09 and SD of 0.82 suggest that respondents generally agree with the positive statements about genetics, reflecting a favorable perception. Most notably, participants strongly agreed with statements such as "knowledge of genetics is essential for solving real-world biological problems" (M = 4.31, SD = 0.66), "genetics is a fundamental topic in understanding modern biology" (M = 4.27, SD = 0.90), and "understanding genetics helps in making informed decisions about health" (M = 4.27, SD = 0.68). These results indicate a strong recognition of the relevance of genetics to both biological science and everyday decision-making.

Furthermore, perceptions were also high regarding the impact of genetics on daily life (M = 4.25, SD = 0.67) and its connection to scientific and medical breakthroughs (M = 4.24, SD = 0.67), showing that students are aware of its broader societal significance. However, the item "genetics is a simple subject that is easy to relate to real life" received a lower M score of 3.56 with the highest SD (1.07), indicating a more varied and less confident perception among students about the simplicity of genetics. Additionally, while statements like "the concepts in genetics are relevant to my future teaching career" (M = 3.96, SD = 0.93) and "advances in genetics influence ethical and social issues that should be discussed in schools" (M = 3.84, SD = 0.96) scored within the "agree" range, they also had relatively higher SDs, pointing to diverse viewpoints. Overall, the data suggest that pre-service teachers hold genetics in high regard and perceive it as an essential and impactful area of study, though some complexity and variation in understanding remain.

What Is the Attitude of Pre-Service Science Teachers Towards the Study of Genetics?

Similarly, following the same common practice (Sullivan & Artino, 2013; Yin et al., 2016) stated in **Table 3**. A descriptive statistic (M and SD) was conducted to assess the attitude of pre-service science teachers towards the study of genetics.

Table 4 explores the attitudes of pre-service science teachers toward genetics. The overall M score of 3.95 and SD of 0.93 suggest a generally positive attitude, falling within the "agree" range. The highest-rated item, "I am interested in how genetics can be applied in real-life situations" (M = 4.20, SD = 0.72), indicates that students see the practical relevance of genetics and are motivated by its applications. Similarly, items like "I would choose to attend a workshop or seminar on genetics if given the opportunity" (M = 4.06, SD = 0.90) and "learning about genetics makes science more exciting to me" (M = 4.02, SD = 0.96) reflect an enthusiasm to engage more deeply with the subject beyond classroom learning.

Other attitude-related items, such as "I enjoy learning about genetics" (M = 3.87, SD = 0.98), "I feel motivated to learn more about genetics beyond the classroom" (M = 3.86, SD = 0.99), and "I am curious about new discoveries in genetics" (M = 3.87, SD = 0.90), reinforce the idea that students are both interested in and motivated to explore genetics further. However, certain items reveal areas of modestly lower enthusiasm or varied responses. For example, "genetics is one of my favorite science topics" (M = 3.64, SD = 1.08) received the lowest M score, and the highest SD in **Table 4**, suggesting that while many students enjoy genetics, others may not consider it a preferred topic. Additionally, "I feel confident discussing genetic topics with others" (M = 3.85, SD = 0.99) reveals that some students may still lack confidence in articulating their

Table 5. Model summary

R	R^2	Adjusted R^2	Standard error of estimate
.22	.05	.03	9.44

understanding, possibly indicating a need for more discussion-based learning opportunities.

In conclusion, the attitudes of pre-service teachers toward genetics are largely positive, with strong indications of interest, curiosity, and willingness to learn. Nevertheless, the moderate variability in responses across items related to preference and confidence suggests that while enthusiasm exists, there is room to strengthen students' comfort and engagement with the subject through more applied and participatory teaching strategies.

What Is the Association Between Pre-Service Science Teachers' Perception, Attitude, and Their Performance in Genetics?

A multiple linear regression was conducted to examine whether perception and attitude of pre-service science teachers significantly predicted their performance in genetics. The model summary (**Table 5**) indicated that perception and attitude together explained only a small portion of the variance in pre-service science teachers' performance in genetics. The multiple correlation coefficient was R = .22, and the coefficient of determination (R^2) was .05, suggesting that just 5% of the variance in performance was accounted for by the two predictors. After adjusting for the number of predictors, the adjusted R^2 dropped to .03, reinforcing the limited predictive power of the model. The standard error of the estimate was 9.44, which means that, on average, the predicted scores differed from the actual performance scores by about 9.4 points. Overall, these results suggest that the model had weak explanatory power.

Table 6 assessed the overall significance of the regression model. The results showed that the model was not statistically significant, F (2, 98) = 2.50, p = .087. This means that the combined influence of perception and attitude on students' performance in genetics was not strong enough to be considered statistically meaningful at the conventional alpha level of .05. While the p-value was somewhat close to the threshold, it does not provide sufficient evidence to conclude that perception and attitude, taken together, significantly predict performance outcomes. This confirms the model's weak explanatory power observed in the model summary.

The results of the multiple linear regression analysis provide insight into the extent to which pre-service science teachers' perception and attitude towards genetics predict their academic performance in the subject. The model summary (**Table 5**) reveals that the combined variables; perception and attitude, accounted for a very small portion of the variance in performance outcomes. Specifically, the R-value of .22 indicates a weak positive correlation between the predictors and performance, while the R^2 value of .05 shows that only 5% of the variation in genetics performance among the students can be explained by their perception and attitude. This means that 95% of the variation in performance is attributed to other factors not included in the model. The adjusted R^2, which corrects for the number of predictors, further dropped to .03, reinforcing the model's limited predictive power. Additionally, the standard error of the estimate (9.44) suggests that the predictions made by the model differ from the actual performance scores by approximately 9.4 points on average; a considerable amount in educational research terms.

Table 6. ANOVA summary

Source	Sum of squares	df	MS	F	p
Regression	445.67	2	222.83		
Residual	8,723.70	98	89.02	2.50	.087
Total	9,169.37	100			

The ANOVA table (**Table 6**) was used to evaluate the overall significance of the regression model. The result, F (2, 98) = 2.50, p = .087, indicates that the model was not statistically significant at the conventional alpha level of .05. While the p-value of .087 is close to the threshold, it is not low enough to reject the null hypothesis that perception and attitude do not significantly predict genetics performance. This implies that, although there is a slight indication of an effect, the model does not provide strong enough evidence to confirm that perception and attitude meaningfully influence performance outcomes in this context. Thus, the model, as constructed, does not significantly improve our ability to predict students' performance based on their perception and attitude.

An examination of the individual regression coefficients (**Table 7**) further supports this conclusion. The regression constant, or intercept, was statistically significant (B = 54.04, p < .001), suggesting that when both perception and attitude are at zero, the average expected performance score is approximately 54. However, neither perception nor attitude individually predicted performance in a statistically significant way. The coefficient for perception was B = -1.06 with a p-value of .701, indicating a very weak and statistically insignificant negative relationship with performance. This suggests that higher perception scores were slightly associated with lower performance scores, but this result is both small and unreliable. In contrast, the coefficient for attitude was B = 3.60, with a standardized beta (β) of .27, suggesting a moderate positive relationship. However, this relationship also did not reach statistical significance (p = .103), meaning we cannot confidently claim that attitude alone is a meaningful predictor of performance, even though it trends in a positive direction.

DISCUSSION AND CONCLUSIONS

Perception of Pre-Service Science Teachers Towards the Study of Genetics

The findings in **Table 3** reveal that pre-service science teachers generally hold a positive perception of genetics, with an overall M of 4.09, placing their responses in the "agree" category. The data indicate that the respondents recognize genetics as an essential and impactful component of science. For instance, the highest-rated statement, "knowledge of genetics is essential for solving real-world biological problems" (M = 4.31), suggests that students value the practical applications of genetics. Similarly, items such as

Table 7. Multiple regression coefficients predicting genetics performance

Predictor	B	Standard error B	β	t	p
Intercept	54.04	6.87	-	7.87	.000
Perception of students	-1.06	2.74	-0.06	-0.39	.701
Attitude of students	3.60	2.19	0.27	1.64	.103

"genetics is a fundamental topic in understanding modern biology" (M = 4.27) and "understanding genetics helps in making informed decisions about health" (M = 4.27) reflect a belief in genetics' importance in both biological science and personal life.

These findings support earlier work by Dougherty et al. (2011), who emphasized that genetics is foundational for making informed health and ethical decisions in modern society. Also, Eddy et al. (2015) observed that students perceive genetics as highly relevant when it is framed within societal and technological contexts. Interestingly, the high Ms on statements concerning medical breakthroughs and everyday impact (M = 4.24-4.25) demonstrate that the participants recognize genetics not only as an academic subject but also as a scientifically and socially significant discipline.

However, the statement "genetics is a simple subject that is easy to relate to real life" (M = 3.56, SD = 1.07) received the lowest M and highest variability, indicating that while students value the subject, they may struggle with its conceptual complexity. This aligns with literature that identifies genetics as one of the more abstract and difficult topics in science education (Duncan & Reiser, 2007; Lewis & Kattmann, 2004). Students' varied responses also suggest gaps in instructional strategies that may not adequately support learners in relating complex content to real-world contexts.

Overall, the findings demonstrate that pre-service teachers perceive genetics as meaningful and relevant, especially in real-life problem solving, health education, and science literacy. These results point to the importance of maintaining a context-based and interdisciplinary approach to genetics instruction, which research has shown to enhance perception and understanding (Schmidt et al., 2007).

Attitude of Pre-Service Science Teachers Towards the Study of Genetics

The overall attitude M (M = 3.95, SD = 0.93) indicates that the pre-service teachers generally agreed with positive statements about genetics, particularly those emphasizing real-life applications and willingness to engage further (e.g., attending workshops). This pattern is consistent with evidence that active, student-centered designs can strengthen interest and reduce anxiety around genetics learning by giving learners structured opportunities to apply ideas and receive feedback (Borja & Mutya, 2024). However, variability in items linked to preference and confidence suggests that enjoyment does not always translate into communicative confidence, reinforcing the need for discussion-rich and misconception-focused pedagogy in teacher education (Ojo, 2024; Pacaci et al., 2023).

Several other statements, such as "I would choose to attend a workshop or seminar on genetics" (M = 4.06) and "learning about genetics makes science more exciting" (M = 4.02), further affirm that students are enthusiastic and willing to explore the subject beyond traditional classroom boundaries. These findings align with Jones et al. (2013), who found that explicit and hands-on teaching approaches in genetics increased students' excitement and desire for further learning. Students also expressed curiosity about new discoveries (M = 3.87) and enjoyment in learning genetics (M = 3.87), reinforcing the notion that genetics evokes a sense of wonder when appropriately taught.

However, the item "genetics is one of my favorite science topics" (M = 3.64, SD = 1.08) received the lowest M and the highest variability, indicating that not all students rank genetics among their top interests. Furthermore, the item "I feel confident discussing genetic topics with others" (M = 3.85) suggests that while students have a positive attitude, confidence in articulation and peer discussion may still be underdeveloped. Zohar and Nemet (2002) argue that confidence and argumentation skills in genetics are fostered when students are given opportunities to debate socio-scientific issues, which suggests that current instructional methods may need to incorporate more dialogic practices.

In summary, the findings from **Table 4** confirm that pre-service science teachers exhibit high levels of motivation, interest, and openness toward learning genetics. Nonetheless, variation in preference and confidence levels highlights the need for more engaging, student-centered pedagogies that support both affective development and communication skills in genetics education (Schmidt et al., 2007).

The Association Between Pre-Service Science Teachers' Perception, Attitude, and Their Performance in Genetics

The multiple regression analysis revealed that pre-service science teachers' perception and attitude toward genetics collectively accounted for only 5% of the variance in their performance in genetics. This minimal explanatory power suggests that other factors play a more significant role in influencing academic achievement in this subject area.

The weak predictive power of perception and attitude on performance can be interpreted in light of evidence that misconceptions and representational difficulties often persist even when learners recognize genetics as important. For example, research with senior secondary students has reported high rates of misconceptions alongside generally negative perceptions of genetics, suggesting that affective responses may reflect perceived difficulty rather than conceptual mastery (Ojo, 2024). Reviews of misconceptions also emphasize that transmissive, decontextualized instruction and weak diagnostic feedback can allow alternative conceptions to remain stable (Guerra-Reyes et al., 2024; Herak et al., 2025). Therefore, improving performance in genetics likely requires combining affective support with instruction explicitly designed to challenge prior ideas and promote conceptual change, supported by appropriate representations and resources (Menendez et al., 2024; Pacaci et al., 2023).

Furthermore, Sizer et al. (2021) emphasized the importance of a constructivist teaching approach in science courses in improving pre-service teachers' attitudes toward science. Their study found that engaging, hands-on science courses significantly enhanced attitudes and confidence. However, they also noted that without adequate content knowledge and pedagogical skills, positive attitudes alone might not translate into improved performance.

The integration of technology in science education has been shown to influence pre-service teachers' attitudes and perception. A study by González-Gómez et al. (2022) demonstrated that the flipped classroom model (FCM) positively affected pre-service teachers' science teaching self-efficacy and attitudes toward science. While the FCM improved attitudes and perception, the study did not directly link these improvements to academic performance, suggesting that additional factors contribute to learning outcomes.

In conclusion, while positive perceptions and attitudes toward genetics are beneficial, they are insufficient predictors of academic performance in genetics among pre-service science teachers. Addressing misconceptions, enhancing content knowledge, employing effective pedagogical strategies, and integrating technology thoughtfully are essential to improve academic outcomes in genetics education.

Implications and Recommendations

The findings of this study have several important implications for science education, particularly in the training of pre-service teachers in genetics. Although participants exhibited generally positive perceptions and attitudes toward the study of genetics; recognizing its relevance to real-life applications, health decisions, and scientific advancements; the observed conceptual challenges and variability in responses highlight the need for more context-based and applied instructional strategies. Teacher education programs should therefore incorporate real-world examples, discussions on ethical and social issues, and interactive pedagogies such as debates, workshops, and inquiry-based learning to deepen understanding and foster confidence. The weak predictive power of perception and attitude on actual academic performance in genetics suggests that positive feelings toward the subject alone are insufficient for ensuring academic success. This emphasizes the importance of reinforcing content knowledge, addressing misconceptions, and using diagnostic assessments to tailor instruction. Furthermore, the gap between affective responses and performance implies a need for curriculum reform and improved alignment between teaching methods and assessment practices. Incorporating educational technologies such as the flipped classroom model and digital simulations may also enhance student engagement and understanding. Overall, while nurturing positive attitudes remains essential, these must be supported by robust content delivery and effective teaching strategies to produce competent and confident future educators in genetics.

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