Knowledge as a Predictor of Acceptance of Genetically Modified Foods: The Mediational Pathway of Attitude and its Pedagogical Implications in Teaching Genetic Engineering Among College Students

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ABSTRACT

Non-acceptance of genetically modified foods is still a major challenge. This study examines the mediating role of attitude towards GMO foods between the basic biotechnology knowledge and acceptance of genetically modified foods. Using a predictive research design, the data from 567 respondents, selected via simple random sampling, were analyzed using mediation analysis. It was found that attitude towards genetically modified foods partially but significantly mediates the predictor-criterion correlation, supporting the Knowledge-Attitude-Practice Theory. Future research may explore additional mediating variables through qualitative approaches. Educational leaders and curriculum developers may strengthen biotechnology education and public awareness to enhance acceptance of GMO foods.

Keywords: Knowledge, acceptance of genetically modified foods, attitude towards genetically modified foods, college students

INTRODUCTION

The Problem and its Scope

The issue of non-acceptance of genetically modified foods remains a major challenge, despite significant scientific advancements and the potential benefits of genetic engineering and the commercial production of genetically modified organisms (Hwang & Nam, 2021). People in different countries and communities have very different views on genetically modified crops, even though there is strong evidence that they are safer and produce more. This is because local policy, trust in regulators, and cultural values all play a significant role in how people view these crops (Woźniak-Gientka et al., 2022). This variation in public approval arises from the coexistence of perceived risks and promised benefits, often influenced by a complex interplay of social, cultural, and psychological factors (Siegrist & Hartmann, 2020).

In other European nations, Bt maize, a genetically modified crop, is neither completely accepted nor prohibited, discouraged by onerous regulations, nor outright banned (Sikora & Rzymski, 2021). Countries like Tanzania, Uganda, and Zimbabwe are demonstrating their opposition to genetically modified organisms by implementing stricter regulations that prohibit the cultivation of genetically modified crops (Sadikiel, 2024). A study performed towards social acceptability of GMOs in industrialized countries such as Europe, the United States, Australia, New Zealand, and Japan show that 80% of the survey participants said that they would not accept the said GMOs by not buying them, even though it is less expensive than the traditional one (Spök et al., 2022). It has long been stated that the majority of the European public still has a hesitant attitude regarding the use of genetically modified organisms, in contrast to the positive views of EU specialists on the subject (Ichim, 2021).

In the Philippines, local government units are not accepting the GMOs and have passed ordinances prohibiting the introduction of genetically modified crops into their communities. Bohol became the first GMO-free Island in the Philippines when it approved Resolution 2003-235 (Pasquito, 2019). In another study analyzing farmers' perceptions of the banning of genetically modified crops, 35% of respondents said the decision to enforce the ban was the right one, indicating they also do not accept any genetically modified crops (Gonzalvo et al., 2022).

Lastly, the introduction of the Bt cotton adoption here in the Philippines is not accepted by indigenous weavers (Angeles-Shim & Vergara, 2025).

Citizens are at risk of accepting misconceptions that undermine technology acceptance and, consequently, hinder the development of innovative solutions to global problems (Spreen & Klimmt, 2024). However, most existing research focuses on general public or consumer perceptions, overlooking the perspectives of students who will become future consumers, professionals, and decision-makers (Palmieri et.al., 2025). This creates a gap in understanding how knowledge and attitudes influence acceptance of GMOs, particularly within educational contexts. Given the rapid growth of biotechnology and the limited biotechnology literacy in the Philippines, there is an urgent need to equip students with accurate knowledge and positive attitudes toward GMOs (Co et.al., 2021). Addressing this gap is crucial for developing effective educational strategies that foster informed decision-making and responsible participation in food security and technological advancement. Hence, this study was conducted.

Significance of the Study

This study highlighted how biotechnology knowledge affects the acceptability of genetically modified foods, with attitude acting as a key mediating factor. Emphasizing the influence of attitude on acceptance, it expands the scope of previous research. It provides educators and curriculum designers with useful insights to enhance scientific literacy and encourage students to adopt balanced, evidence-based viewpoints. The findings support increased public trust, better-informed consumer behavior, and greater support for biotechnology in food security and public health.

The result of this study aligns with numerous Sustainable Development Goals (SDGs) of the United Nations. It mainly supports SDG 3: Good Health and Well-Being, which promotes the goal of ensuring healthy lives and fostering well-being for all. Genetically modified foods play an increasingly important role in global food systems by offering potential benefits such as enhanced nutritional content, reduced allergenicity, improved crop resilience, and more stable food supplies. It also helps to achieve SDG 4: Quality Education by promoting the integration of genetic engineering and biotechnology into science literacy. It helps teachers design engaging, evidence-based lessons that address misconceptions and encourage analytical thinking, while guiding curriculum designers to create relevant, context-driven materials that connect science learning to real-world issues like food security and sustainability. Furthermore, by encouraging responsible and informed decision-making in biotechnology and sustainable food production, the research aligns with SDG 12: Responsible Consumption and Production. As a result, this study not only enriches academic debate on biotechnology adoption but also strengthens worldwide efforts toward sustainable development and food system resilience.

Statement of the Problem

It was aimed in this study to determine the mediating effect of attitude towards genetically modified foods on the correlation between basic biotechnology knowledge and acceptance of genetically foods among college students. Specifically, the following objectives were pursued:

1. To determine the level of basic biotechnology knowledge in terms of laboratory methods and techniques, real-life practices, and effects of biotechnology; attitude in terms of GMO implications on health, interest in the topic of GMO, GMO implications on the environment; acceptance of genetically modified foods in terms of perceived benefits, perceived risks, and willingness to eat genetically foods crops among college students;

2. To determine the significance of the correlation between knowledge, attitude, and acceptance of genetically modified foods among college students;

3. To determine the significance of the direct effect of basic biotechnology knowledge on acceptance of GMO foods, controlling for attitude towards GMO foods;

4. To determine the significance of the indirect effect of basic biotechnology knowledge on acceptance of GMO foods, through attitude towards GMO foods; and

5. To determine the significance of the total effect of basic biotechnology knowledge on acceptance of GMO foods.

Hypotheses

Ho1: Basic biotechnology knowledge and attitude towards genetically modified foods do not significantly correlate with acceptance of genetically modified foods among college students.

Ho2: The direct effect of basic biotechnology knowledge on acceptance of GMO foods, controlling for attitude towards GMO foods, is not significant.

H03. The indirect effect of basic biotechnology knowledge on acceptance of GMO foods, through attitude towards GMO foods, is not significant.

H04. The total effect of basic biotechnology knowledge on the acceptance of GMO foods is not significant.

Theoretical Framework and Conceptual Framework

This study is grounded in the Knowledge-Attitude-Practice (KAP) theory, originally articulated by Everett M. Rogers in 1962. The KAP model posits that human behavior follows a sequential pathway: individuals first acquire knowledge, which then shapes their attitudes, and ultimately leads to the development of practices or behavior. Knowledge provides the foundation for informed judgment, attitude serves as the motivational force influencing perceptions and predispositions, and practice represents the behavioral outcome (Launiala, 2009). In the context of this study, students' basic biotechnology knowledge serves as the cognitive foundation (knowledge) for forming attitudes toward genetically modified (GM) foods. When students have accurate knowledge, they are more likely to develop positive and open attitudes toward biotechnology; however, limited or incorrect knowledge often leads to fear or skepticism (McPhetres et al., 2019). Attitudes towards genetically modified foods connect to the affective component (attitude). If students are knowledgeable, their acceptance of GM foods depends on how they feel about the technology (Veličković et al., 2016). Lastly, the acceptance of genetically modified food represents the practice aspect of the theory, reflected in students' willingness to consume or support GM products. By applying the KAP theory, this study provides a foundation for developing educational strategies that strengthen understanding and foster positive, informed perspectives on biotechnology. Hence, this study is fully anchored on the Knowledge-Attitude-Practice Theory.

Figure 1. Conceptual Framework of the Study

METHOD

Included in this chapter are the research design, locale of the study, sample and sampling technique, data gathering technique, data analysis technique, and ethical consideration.

Research Design

This study utilized a predictive research design. A predictive research design is a type of quantitative, non-experimental research design that examines the relationship between two or more variables and uses the strength and direction of these relationships to predict the value of one variable based on another (Creswell & Creswell, 2018). It is a predictive research design as it examines the relationship between basic biotechnology knowledge and acceptance of genetically modified foods, and whether attitude towards genetically modified foods mediates that relationship.

Locale of the Study

The study was conducted at two selected Davao Association of Catholic Schools (DACS) in Davao City, Philippines. The DACS refers to an association of private Catholic educational institutions, both basic and higher education, operating under the dioceses in the Davao region. It is a non-stock, non-profit membership of catholic schools. There are 71 schools that are members of this association. The DACS colleges were chosen as the research locale because they provide a suitable environment for examining students' knowledge, attitude, and acceptance of genetically modified organisms (GMOs). These colleges share a common philosophy that promotes critical thinking, ethical reflection, and scientific understanding, the key elements in shaping perceptions of biotechnology. Their diverse student population allows for a representative view of future consumers and professionals. Moreover, the study supports DACS's mission of advancing quality, values-based education and contributes to improving science instruction and curriculum development aligned with SDG 4: Quality Education.

Sample and Sampling Technique

This study involved 576 respondents. The criteria for selecting the respondents include the following: (a) a bona fide first-year college student of DACS; (b) currently enrolled in the STS science, technology, and society subject for the academic year 2025-2026; (c) either male or female, and 18 years old and above. The exclusion criteria are the following: a) students who were absent during the collection of data, and b) students who were not able to answer the questionnaire completely.

This study utilized simple random sampling. Simple random sampling is a probability sampling technique in which every member of the population has an equal and independent chance of being selected for the study. This method relies on random selection procedures, such as lottery methods or random number generators, to ensure fairness and reduce selection bias. According to Thomas (2023), simple random sampling is "a randomly selected subset of a population" where "each member of the population has an exactly equal chance of being selected.

Data Gathering Technique

The survey technique was used in gathering data. This technique is a systematic method for collecting information from a sample using structured questionnaires to describe the characteristics, opinions, or behaviors of a larger population, and it is applied in research to efficiently assess, test, or generalize findings across a defined group (Sheikh et al., 2024). The researcher utilized an adapted survey instrument to gather data. The independent variable questionnaire was derived from the study by Aydin et al. (2022). It measures the students' basic biotechnology knowledge. The dependent variable questionnaire was derived from the study by Bourgonion, Gheysen, and Valcke (2017). It measures students' acceptance of genetically modified organisms. Lastly, the mediating variable questionnaire was derived from the study by Herodotou, Kyza, Nicolaidou, Hadjichambis, Kafouris, and Terzian (2012). This measures the students' attitude towards genetically modified foods. The researcher has 14 items on basic biotechnology knowledge, 11 on attitude towards genetically modified foods, and 8 on acceptance of genetically modified organisms. The questionnaire consisted of 33 items.

The respondents used this 4-point Likert scale to answer the questionnaire: 1 as Strongly Disagree, 2 as Disagree, 3 as Agree, and 4 as Strongly Agree.

All three questionnaires were adapted, modified, and validated to align with the respondents' background and the study's objectives. Each used a Likert scale with specific indicators describing respondents' current conditions. Moreover, they were subjected to reliability testing, and all items obtained a Cronbach's alpha of 0.95, confirming the high reliability of these tools.

Data Analysis Technique

In this study, the data analysis techniques used were descriptive, correlation, and mediation analysis. Descriptive analysis helps organize and summarize large amounts of data, making it easier for researchers to understand real-world patterns while saving time, no matter the situation or field of study (Costa, 2024). In this study, the mean and standard deviation were used as statistical tools. Moreover, the correlation analysis examines the strength and direction of the relationship between two continuous variables (Rizk, 2023). The Pearson Product-moment correlation statistical tool was used. Lastly, mediation analysis separates the overall effect of the treatment into two parts: the indirect effect, which operates through one or more middle factors, or mediators, and the direct effect, which explains the remaining part of the outcome that is not caused by those mediators (Celli, 2022). The beta-estimate statistical tool for the direct, indirect, and total effects of the determinant was used.

The matrix below outlines the scale, descriptive level, and corresponding interpretation for each variable in this study. This measure is used particularly to describe levels of basic biotechnology knowledge, attitudes towards genetically modified foods, and acceptance of genetically modified foods.

Scale	Level	Basic Biotechnology Knowledge	Attitude Towards Genetically Modified Foods	Acceptance of Genetically Modified Foods
3.26 – 4.00	very high	Very good	Always Strong	Always Strong
2.50 – 3.25	high	Good	Strong	Strong
1.75 – 2.49	low	Poor	Weak	Weak
1.00 – 1.74	very low	Very poor	Very Weak	Very Weak

Standard Deviation Value Ranges and Interpretation

Range	Description	Interpretation
SD ≤ 0.50	High Consistent Responses	Strong and uniform perception
SD = 0.51 – 1.00	Moderate Consistent Responses	Acceptable consistency
SD = 1.01 – 1.50	Low Consistent Responses	Differing views or experiences
SD > 1.50	Very Low Consistent Responses	High variability and lack of consensus

In this study, the significance of the correlation is tested at 0.05 confidence level. The following is the standard measure for the interpretation scale of r-value, the following scheme was used:

Computed r	Descriptive Interpretation
+/- 1.00	Perfect correlation
Between +/- 0.75 – +/- 0.99	High correlation

Between +/- 0.51 – +/- 0.74 Moderately high correlation

Between +/- 0.31 – +/- 0.50 Moderately low correlation

Between +/- 0.01 – +/- 0.30 Low correlation

0.00 No correlation

The standard measure for the interpretation of the strength of the mediation is as follows:

Proportion Mediated	Interpretation
< 0.20	Weak Mediation
0.20 – 0.50	Moderate Mediation
> 0.50	Strong Mediation

Ethical Considerations

Respondents were fully informed about the study's purpose, procedures, and their right to withdraw at any time, and informed consent was obtained prior to data collection. Participants' identities will remain confidential through the use of anonymized data and secure storage systems, with access limited solely to the research team. The study was designed to prevent harm, ensuring that participants are fully aware of their rights and are free to withdraw at any point without penalty. The research was conducted with honesty, integrity, and respect, safeguarding participants' privacy and recognizing the value of their contributions. Ethical approval was secured from the SMILE Ethics Board, and permission to conduct the study was respectfully sought and obtained from the Vice President for Academic Affairs (VPAA). Efforts have been made to maximize benefits, minimize potential risks, and ensure fairness throughout the research process, with findings reported transparently and any potential conflicts of interest properly disclosed to uphold the integrity of the research.

RESULTS

Included in this chapter are the results of the descriptive, correlation, and mediation analysis. The summary of findings is also presented.

Descriptive Results

Table 1 is descriptive. Shown in Table 1 are the mean, standard deviation, and descriptive interpretation of respondents' basic biotechnology knowledge, attitude towards genetically modified foods, and acceptance of genetically modified foods.

Table 1. Descriptive Statistics (N = 576)

Variable	Standard Deviation	Mean	Descriptive Level
Basic Biotechnology Knowledge	0.420	3.18	High
Laboratory Methods and Techniques	0.593	3.15	High
Real-Life Practices	0.608	3.18	High
Effects of Biotechnology	0.562	3.22	High
Attitude Towards Genetically Modified Foods	0.433	3.19	High

Genetically Modified Food Implications on Health	0.591	3.23	High
Interest in the Topic of Genetically Modified Food	0.622	3.16	High
Genetically Modified Food Implications on the Environment	0.579	3.19	High
Acceptance of Genetically Modified Foods	0.537	3.16	High
Perceived Benefits	0.629	3.16	High
Perceived Risks	0.608	3.21	High
Willingness to Eat Genetically Modified Foods	0.622	3.13	High

Specifically, the table shows that the basic biotechnology knowledge variable obtained a mean of 3.18, described as high. This indicates that the respondent's basic biotechnology knowledge is good. All indicators obtained a high level. The standard deviation of 0.42, is described as high consistent, indicating strong and uniform perception. Furthermore, the attitude towards genetically modified foods obtained a mean of 3.19, described as high. This indicates that respondents' attitudes towards genetically modified foods are strong. All its indicators are described as high-level. The standard deviation of 0.43, described as high consistent denoting strong and uniform perception. Finally, the acceptance of genetically modified foods variable had a mean of 3.16, indicating a high level of acceptance. This signifies that the respondent's acceptance of genetically modified foods is strong. Consistently, all indicators are described as high-level. The standard deviation of 0.53, described as moderate and consistent, indicates acceptable consistency in the responses.

Basic biotechnology knowledge, attitude towards genetically modified foods, and acceptance of genetically modified foods are all interpreted at a high level, indicating a strong cognitive foundation in basic biotechnology concepts, a positive attitude towards genetically modified foods, and a general willingness to accept genetically modified foods.

Correlation Results

Table 2 is correlational. It presents the determinant and criterion variables. It shows the r-value, p-value, decision on the null hypothesis, and the corresponding interpretation.

Table 2: Correlation Table (N=576)

Variables	Acceptance of Genetically Modified Foods			
	r-value	p-value	Decision on H_0	Interpretation
Basic Biotechnology Knowledge	0.694	0.000	Reject H_{01}	Moderately High, significant correlation
Attitude Towards Genetically Modified Fooods	0.740	0.000	Reject H_{01}	Moderately High, significant correlation

Level of Significance: 0.05, Decision Rule: Reject H_0 if $p < 0.05$

Specifically, the table shows that the correlation between Basic Biotechnology knowledge and Acceptance of Genetically Modified Foods variables obtained a p-value of 0.000, which is lower than the 0.05 level of significance; hence, the null hypothesis is rejected, indicating that the correlation is statistically significant. The

r-value of 0.694 reflects a moderately high correlation between basic biotechnology knowledge and acceptance of genetically modified foods. It implies that for every unit change in this basic biotechnology knowledge, there is a corresponding unit change in the acceptance of genetically modified foods. Similarly, Attitude Towards Genetically Modified Foods yielded a p-value of 0.000, which is lower than the 0.05 level of significance; hence, the null hypothesis is rejected, indicating that the correlation is statistically significant. The r-value of 0.740 reflects a moderately high correlation between attitude towards genetically modified foods and acceptance of genetically modified foods variables. This implies that attitudes towards genetically modified foods play a significant role in influencing students' acceptance, indicating that perceptions, beliefs, and evaluations of genetically modified foods can strongly influence acceptance.

Both basic biotechnology knowledge and attitude toward genetically modified foods showed statistically significant correlations with acceptance of genetically modified foods, indicating that each factor is strongly associated with students' acceptance. However, attitude demonstrated a slightly stronger correlation than knowledge, suggesting that students' perception and evaluation of genetically modified foods may have a greater influence on acceptance than knowledge alone.

Mediation Results

Table 3 is a mediation table. It contains the path/effect, estimate Beta, standard error, Z-value, p-value, decision on null hypothesis and corresponding interpretation.

Table 3. Mediation Table (N = 576)

Label	Path/Effect	Estimate (B)	SE	z-value	p-value	Decision on H_0	Interpretation
A	Basic Biotechnology Knowledge → Attitude Towards Genetically Modified Foods	1.831	0.063	28.926	0.000	Reject	Significant
B	Attitude Towards Genetically Modified Foods → Acceptance of Genetically Modified Foods	0.506	0.042	12.052	0.000	Reject	Significant
C	Basic Biotechnology Knowledge → Acceptance of Genetically Modified Foods	0.725	0.100	7.251	0.000	Reject	Significant
c’	Direct	0.725	0.100	7.251	0.000	Reject	Significant
a x b	Indirect	0.927	0.083	11.125	0.000	Reject	Significant
c	Total	1.651	0.071	23.129	0.000	Reject	Significant

Note. Bootstrap Replications: 5000; R^2 Acceptance of Genetically Modified Foods = 0.586; R^2 Attitude Towards Genetically Modified Foods = 0.592

Level of Significance: 0.05
Decision Rule: Reject H_0 if $p < 0.05$

Proportion Mediated: indirect effect/ total effect = 0.56

The table specifically shows that the direct effect of basic biotechnology knowledge on acceptance of GMO foods, controlling for the attitude towards GMO foods variable, yielded an estimated Beta of 0.725. The corresponding p-value of 0.000 is less than the 0.05 level of significance. Hence, the null hypothesis was rejected. This indicates the direct effect of basic biotechnology knowledge on acceptance of GMO foods; controlling for attitude towards GMO foods is significant. Furthermore, the indirect effect of basic biotechnology knowledge on acceptance of GMO foods through attitude towards GMO foods obtained an estimated Beta of 0.927. The corresponding p-value of 0.000 is less than the 0.05 level of significance. Hence, the null was rejected. This indicates that the indirect effect of basic biotechnology knowledge on the acceptance of GMO foods, operating through attitudes towards GMO foods, is significant. Lastly, the total effect of basic biotechnology knowledge on acceptance of GM foods and on controlling attitude towards GMO foods resulted in an estimated Beta of 1.651. The corresponding p-value of 0.000 is less than the 0.05 level of significance; the null was rejected. This indicates that the total effect of basic biotechnology on basic biotechnology knowledge is significant.

The table likewise specifies the mediated proportion, 0.561, indicating that the strength of attitude towards GMO foods in mediating the correlation between basic biotechnology knowledge and acceptance of GMO foods is strong. Since the direct effect of biotechnology knowledge is significant on acceptance of GMO foods, the indirect effect of basic biotechnology knowledge on acceptance of GMO foods is significant through attitude towards GMO foods, thus the attitude towards GMO foods mediation is significant.

SUMMARY OF FINDINGS

Based on the statistical results, it was found that:

Basic biotechnology knowledge and attitude towards genetically modified foods significantly correlate with acceptance of genetically modified foods among college students.

The direct effect of basic biotechnology knowledge on acceptance of GMO foods, controlling for attitude towards GMO foods, is significant.

The indirect effect of basic biotechnology knowledge on acceptance of GMO foods, through attitude towards GMO foods, is significant.

The total effect of basic biotechnology knowledge on the acceptance of GMO foods is significant.

CONCLUSION

Based on the findings, attitude towards genetically modified foods partially but significantly mediates the relationship between basic biotechnology knowledge and acceptance of genetically modified foods. Hence, the Knowledge-Attitude-Practice (KAP) Theory, which posits that knowledge influences attitudes that subsequently shape behavioral responses, was fully supported.

Recommendations

Based on the findings of the study, the following recommendations are proposed:

1. Educational leaders may strengthen biotechnology education by incorporating real-life applications and critical discussions to deepen understanding and improve attitudes.

2. Curriculum developers may integrate interdisciplinary approaches that connect biotechnology with societal and environmental issues to enhance both knowledge and acceptance.

3. Future researchers may explore additional mediating variables, such as trust, risk perception, and ethical considerations, to account for the remaining 44% of the variance in the strength of the mediation.

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