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Genetic Engineering in the Eyes of Future Engineers: Awareness, Attitudes, and Educational Implications

Reden E. Nolasco
University of Saint Louis, Tuguegarao, Philippines

Author Email: rednolasco@usl.edu.ph

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Abstract. This study aimed to add to the limited research on engineering students' perceptions of genetic engineering (GE), knowing that little is known about engineering students' awareness, attitudes, and perceptions of GE applications in the Philippine context. This research aimed to determine engineering students' awareness of GE applications and attitudes toward GE, and how research explores the possibilities of incorporating this in interdisciplinary courses, such as Chemistry for Engineers. Using a descriptive survey design, this study gathered data from sixty former first-year engineering students of a Catholic university who previously completed Chemistry for Engineers. A validated questionnaire sought demographic information, awareness of ten applications of GE, attitudes using a Likert scale, and open-ended perceptions. Quantitative data are analyzed using descriptive statistics, and qualitative data undergo thematic analysis. Overall, the results found high awareness of popularized applications, like cloning, DNA forensics, GM crops, and mRNA vaccines, but low awareness of more modern applications like CRISPR. Students reported generally positive attitudes toward GE applications in health and agriculture, but also expressed concerns regarding ethical and environmental implications. Students' awareness and attitudes towards GE varied based on strand or cluster, gender, and exposure to media. STEM students demonstrated greater awareness of GE applications and more favorable attitudes, as this strand typically uses science media. Students exposed more frequently to science media had more familiarity and generally positive views toward GE applications. The open-ended responses emphasized curiosity, perceived advantages in health (medicine) or agricultural and environmental management, and a need for clarity. The research findings show that infusing GE topics into Chemistry for Engineers helps engineering students advance scientific literacy, develop critical thinking, and position them to engage with emerging biotechnologies responsibly.

Keywords: Biosafety; Chemistry education; Genetic engineering; Interdisciplinary teaching; Engineering students

1.0 Introduction

Genetic engineering (GE) is an evolving and dynamic area of research with widespread implications for agriculture, medicine, industry, and environmental remediation. Key methods such as recombinant DNA technology, CRISPR-Cas genome editing, and synthetic biology have allowed for the creation of genetically modified organisms (such as crops and food products), new gene therapies to target disease, and bioengineered microorganisms for bioremediation and production of biofuels (Rathod & Hedaoo, 2022; Ramos et al., 2023). While these advancements have numerous benefits, ethical, ecological, and safety concerns also arise, making informed public discussion imperative (World Health Organization, 2021).

It is therefore important to create awareness and understanding of this topic for students to equip them for relevant future professional practice and public discourse. Available evidence suggests that students with previous formal science education generally present with greater knowledge and more favorable attitudes to GE than those who do not have science education. Generally, however, such knowledge of GE is in familiar technology, such as cloning and GM crops, rather than newer innovations, such as gene editing (Zhang et al., 2022; Calabrese et al., 2021). Some official educational and science communication projects improved knowledge and acceptance of GE (Chrispeels et al., 2019; Jimenez et al., 2022).

In the Philippines, the Department of Science and Technology's National Committee on Biosafety (DOST-NCBP) has already implemented initiatives, and UP Diliman has conducted campaigns like #GeneTalks to raise public knowledge and awareness and to clarify misconceptions about biotechnology (DOST-NCBP, 2024; UP Diliman College of Science, 2024). However, limited scholarship exists on engineering students' attitudes toward GE, particularly related to an interdisciplinary course combining chemistry and biotechnology.

Because Chemistry for Engineers has begun to touch upon principles like molecular interactions, chemical bonding, and reaction mechanisms, it provides an entry point to introduce the chemical foundations of genetic engineering. In classroom conversation, an early observation was that students clearly displayed curiosity in GE applications - even though these applications were not yet included in the formal curriculum - suggesting an educational opportunity. As a result, this study explores first-year engineering students' awareness and attitudes toward genetic engineering applications and possible indications of how interdisciplinary teaching in chemistry may affect their awareness and attitudes. It is guided by two theoretical frameworks: Constructivist Learning Theory, which explains how learners build new knowledge, and the Diffusion of Innovations Theory, which examines how new ideas spread within a community.

2.0 Methodology

The procedures and methods used to collect and analyze the study's data on the awareness and attitudes of first-year engineering students toward genetic engineering applications are described in this section. It describes the study's instrument, participants, location, data collection procedures, data analysis methods, and ethical considerations. The methodology was developed to guarantee that the findings adhere to ethical research standards and accurately reflect the respondents' perceptions.

2.1 Research Design

This research employed a descriptive survey design to determine first-year engineering students' awareness and perception of different uses of genetic engineering. The design was chosen because it enables the systematic collection and presentation of quantitative and qualitative data, describing the status of the variables under investigation without manipulation. It also enables the detection of trends, patterns, and associations between awareness, attitudes, and some demographic variables (e.g., strand). The survey's descriptive nature permitted the researcher to collect information from the respondents directly, reflecting on their perceptions during data gathering.

2.2 Participants and Sampling Technique

The study's participants were former first-year engineering students in a Catholic University in Tuguegaro City, Cagayan, who finished the Chemistry for Engineers course during the second semester of the 2024–2025 academic year. Only sixty (60) students voluntarily answered the survey, even though all eligible students in the class were invited to participate through total enumeration. Civil engineering, computer engineering, electrical engineering, electronics engineering, and geodetic engineering were among the engineering programs from which these responders were drawn.

2.3 Research Instrument

Data were collected using a structured questionnaire created by the researcher with four sections. The first section asked demographic questions (age, gender, senior high school strand, frequency of exposure to science-related content). The second section contained an awareness checklist related to ten applications of genetic engineering, where respondents indicated whether they were familiar with each application. The third section included an attitude scale containing ten statements about respondents' attitudes towards genetic engineering that were to be rated on a 5-point Likert Scale ranging from Strongly Disagree to Agree Strongly. The final section contained open-ended questions asking respondents to identify any perceived benefits or risks of genetic engineering and indicate any remaining questions or concerns. Subject-area experts validated the questionnaire for clarity and content validity before administering it. Its overall reliability was established with a Cronbach's alpha coefficient of 0.82.

2.4 Data Gathering Procedure
Google Forms was used to administer the survey online for convenience and accessibility. Respondents were given an informed consent statement outlining the study's objectives, the voluntary nature of participation, and confidentiality guarantees before their involvement. Over two weeks, responses were gathered, and the researcher monitored submissions to ensure accuracy and completeness.

2.5 Data Analysis Procedure
Quantitative data were examined with descriptive statistics, such as frequency counts, percentages, means, and standard deviation, to profile students' awareness levels and attitudes towards genetic engineering. The frequency and percentage of respondents aware of each application were calculated for the awareness checklist, which followed a multiple-response format. Likert-type attitude items were quantified by calculating mean scores and standard deviations, and differences across demographic categories like strand, gender, and media use were compared. Qualitative data from the open-ended questions were thematically analyzed by extracting, coding, and categorizing recurring ideas within perceived benefits, risks, and concerns regarding genetic engineering.

2.6 Ethical Considerations
The study complied with ethical guidelines for studies involving human subjects. The relevant academic authorities were consulted before any data was collected. All respondents gave informed consent before answering the survey, and participation was completely voluntary. The consent form outlined the study's goals, assured participants that they could leave at any moment without incurring any fees, and underlined that there were no known risks involved in taking part. Confidentiality and anonymity were rigorously preserved by ensuring no personally identifiable information was revealed in the study's findings. All information was safely kept and used only for scholarly research.

3.0 Results and Discussion
This section presents and discusses the study's findings on first-year engineering students' awareness and attitudes toward various applications of genetic engineering. The findings are presented based on the research questions, beginning with awareness, then moving to attitudes toward genetic engineering, patterns that emerged while considering demographic variables, and finally open-ended responses clustered in themes. Quantitative data are provided in frequency and percentage distributions, whereas qualitative responses were analyzed thematically. The discussion section synthesizes the findings with relevant literature and the study's theoretical framework to comprehensively understand the results and implications for unique interdisciplinary topics in the Chemistry for Engineers course.

3.1 Students' Awareness of Genetic Engineering Applications
Table 1 presents the frequency and percentage of respondents familiar with various genetic engineering (GE) applications. The most familiar examples were cloning of plants or animals (43, 71.67%), DNA identification in forensic science (39, 65.00%), using engineered bacteria to clean environmental waste (34, 56.70%), GMOs (genetically modified organisms) in agriculture (30, 50.00%), and GE (genetic engineering) in vaccines, specifically mRNA COVID-19 vaccines (30, 50.00%). These results reflect previous observations that student knowledge was much higher for GE applications frequently discussed in science education and widely disseminated in the media (Rathod & Hedaoo, 2022).

Table 1 *Students' Awareness of Genetic Engineering Applications (N = 60)*

Application	Frequency	Percentage (%)
Genetically Modified Organisms (GMOs) In Agriculture	30	50.00
Gene Therapy for Treating Human Diseases	25	41.67
Production of Synthetic Insulin by Genetically Modified Bacteria	19	31.67
CRISPR Gene-Editing Technology	8	13.33
Cloning of Plants or Animals	43	71.67
Using Engineered Bacteria to Clean Environmental Waste	34	56.70
Genetically Modified Salmon or Livestock	15	25.00
Use of GE in Vaccines (e.g., mRNA COVID-19 Vaccines)	30	50.00
DNA Identification in Forensic Science	39	65.00
Human Embryo Editing ("Designer Babies")	19	31.67

Note: *Respondents could select more than one application; thus, total percentages exceed 100%.*

By contrast, fewer respondents indicated awareness of gene editing using CRISPR technologies (8, 13.33%), genetically modified salmon or livestock (15, 25.00%), genetically modified bacteria producing synthetic insulin (19, 31.67%), human embryo editing or "designer babies" (19, 31.67%), and gene therapy to treat human diseases (25, 41.67%). The public information frame of reference is limited to established GE applications, not the emerging or specialty applications. This reinforces what Zhang et al. (2022) described as the public gap between known and unfamiliar recommended uses of emerging technologies.

This awareness links closely with Constructivist Learning Theory, which discusses how learners use previous knowledge and the available resources to produce knowledge (Piaget, 1972; Vygotsky, 1978). In this regard, the student's awareness of the established GE applications indicates that the level of knowledge is continuously reinforced by consistent exposure to the coursework, media, or public conversations. Meanwhile, the student's access constraints affect awareness of technical or emerging topic areas.

3.2 Students' Attitudes Toward Genetic Engineering

Table 2 highlights respondents' attitudes toward genetic engineering (GE). Many respondents agreed or strongly agreed that GE will improve human health (43.33% agree; 10.00% strongly agree) and, in agriculture, GE could assist in addressing food supply and food security issues (40.00% agree; 15.00% strongly agree). Agreement for this study's respondents was also strong, indicating GE topics should be added to the Chemistry for Engineers course (45.00% agree; 13.33% strongly agree) and for using medicines derived from GE (26.67% agree; 10.00% strongly agree). The strong response about GE and its benefits for health and agriculture is important given the accepted relationship between perceived benefits in those sectors, which is a strong reason for positive attitudes toward GE (Rathod & Hedaoo, 2022).

Table 2 *Students' Attitudes toward Genetic Engineering (n = 60)*

	Application	Strongly Disagree f (%)	Disagree f (%)	Neutral f (%)	Agree f (%)	Strongly Agree f (%)
1.	Genetic engineering can help improve human health.	6 (10.0)	3 (5.00)	19 (31.67)	26 (43.33)	6 (10.00)
2.	Using GE in agriculture can help solve food supply problems.	4 (6.67)	2 (3.33)	21 (35.00)	24 (40.00)	9 (15.00)
3.	Genetic engineering may cause ethical concerns.	4 (6.67)	4 (6.67)	26 (43.33)	22 (36.67)	4 (6.67)
4.	The risks of GE may outweigh its benefits.	2 (3.33)	7 (11.67)	28 (46.67)	18 (30.00)	5 (8.33)
5.	I am willing to use medicine produced through genetic engineering.	5 (8.33)	8 (13.33)	25 (41.67)	16 (26.67)	6 (10.00)
6.	Scientists should be allowed to edit human genes to prevent diseases.	7 (11.67)	6 (10.00)	26 (43.33)	17 (28.33)	4 (6.67)
7.	GE may have adverse effects on the environment.	4 (6.67)	9 (15.00)	23 (38.33)	23 (38.33)	1 (1.67)
8.	The government should strictly regulate genetic engineering.	4 (6.67)	4 (6.67)	27 (45.00)	22 (36.67)	3 (5.00)
9.	I feel comfortable discussing GE topics with other people.	5 (8.33)	3 (5.00)	23 (38.33)	25 (41.67)	4 (6.67)
10.	Genetic engineering topics should be included in chemistry for engineers.	4 (6.67)	2 (3.33)	19 (31.67)	27 (45.00)	8 (13.33)

Note: *Figures in parentheses are percentages.*

However, some caution was also indicated, and over a third of respondents agreed that there were ethical issues associated with using GE (36.67%) and that GE could negatively affect the environment (38.33%). Further, a similar percentage, 36.67%, agreed that the government should have stringent regulations limiting the use of GE. Finding a balance between optimism and caution aligns with the hybrid perspectives Zhang et al. (2022) suggest, where individuals have some confidence in possible benefits but remain uncertain about potential risks.

These patterns are consistent with the diffusion of innovation theory, which suggests that some students (especially those with more exposure to science information) may be viewed as early adopters. However, the majority are in the early or late majority categories, sitting on the fence and waiting for more evidence of safety and benefit to society before jumping in (Rogers, 2003). This also emphasizes the need to focus on both scientific and ethical discussions in engineering education, which can encourage students to produce informed, critical views about emerging technologies.

3.3 Students' Awareness of Genetic Engineering Applications by Strand, Gender, and Media Exposure

Table 3 provides students' awareness of genetic engineering (GE) applications by academic strand, gender, and media exposure. Overall, STEM students showed a greater awareness of GE applications than non-STEM students, with the most substantial differences for DNA identification in forensic science (79.49% STEM versus 20.51% non-STEM) and cloning of plants or animals (69.77% STEM versus 30.23% non-STEM). This supports Rathod and Hedaoo's (2022) findings that formal exposure to biotechnology concepts in science-oriented curricula reflects increased knowledge scores. Chrispeels et al. (2019) suggested that purposeful instructional interventions improve understanding of GE applications for non–science majors.

Table 3 *Students' Awareness of Genetic Engineering Applications by Strand, Gender, and Media Exposure (N= 60)*

	Application	STEM	Non-STEM	Male	Female	Media Exposure (Frequently)	Media Exposure (Occasionally)	Media Exposure (Rarely)
1.	Genetically Modified Organisms (GMOs) in agriculture.	22 (73.33)	8 (26.67)	19 (86.36)	3 (13.64)	12 (40.00)	16 (53.33)	2 (6.67)
2.	Gene therapy for treating human diseases	18 (72.00)	7 (28.00)	14 (77.78)	4 (22.22)	9 (36.00)	14 (56.00)	2 (8.00)
3.	Production of synthetic insulin by genetically modified bacteria.	13 (68.42)	6 (31.58)	10 (76.92)	3 (23.08)	9 (47.37)	8 (42.11)	2 (10.53)
4.	CRISPR gene-editing technology.	7 (87.50)	1 (12.50)	7 (100.0)	0 (0.00)	6 (75.00)	2 (25.00)	0 (0.00)
5.	Cloning of plants or animals.	30 (69.77)	13 (30.23)	24 (80.00)	6 (20.00)	15 (34.88)	25 (58.14)	3 (6.98)
6.	Using engineered bacteria to clean environmental waste.	24 (70.59)	10 (29.41)	18 (75.00)	6 (25.00)	13 38.24)	20 (58.82)	1 (2.94)
7.	Genetically modified salmon or livestock.	10 (66.67)	5 (33.33)	7 (70.00)	3 (30.00)	7 (46.67)	7 (46.67)	1 (6.67)
8.	Use of GE in vaccines (e.g., mRNA COVID-19 vaccines).	25 (83.33)	5 (16.67)	20 (80.00)	5 (20.00)	13 (43.33)	17 (56.67)	0 (0.00)
9.	DNA identification in forensic science.	31 (79.49)	8 (20.51)	23 (76.67)	7 (23.33)	15 (38.46)	20 (51.28)	4 (10.26)
10.	Human embryo editing ("designer babies").	15 (78.95)	4 (21.05)	11 (73.33)	4 (26.67)	10 (52.63)	9 (47.37)	0 (0.00)

Note. Values are presented as frequency (percentage) within each subgroup. Respondents could select more than one application; thus, total percentages per category may exceed 100%.

Awareness of CRISPR gene-editing technology was at its lowest level overall, especially among non-STEM students (12.50%). This supports Ramos et al. (2023), who state that familiarity among the public is most often more established with applications like GM crops and cloning, and not as much newer, more technical innovations that have more than one concept (i.e., technical explanations and contextual framing) that make the concept harder to understand more broadly.

There were also gender differences, as typically male students reported higher awareness than females (e.g., GMOs in agriculture, 86.36% reported awareness vs 13.64%). Heinrich et al. (2020) shared that engagement strategies linking biology concepts to real-world contexts from chemistry are one approach for addressing inequalities based on interest or awareness among diverse learner groups.

Media engagement was an important primary factor. When students reported they consumed science-based media often, they were more informed about both established and emerging applications of GE (for example, CRISPR and GE-based vaccines). This is aligned with the rationale outlined in the DOST–NCBP (2024) program that identified the importance of sharing biotechnology content in diverse educational contexts to reach broader audiences.

The overall patterns in Table 3 reconfirm that curricular emphasis, authentic science communication, and collaborative and interdisciplinary teaching approaches to science education support increased awareness of both established and emerging applications of GE.

3.4 Students' Attitudes Toward Genetic Engineering by Strand, Gender, and Media Exposure

Table 4 displays the mean attitude scores toward genetic engineering (GE) by strand, gender, and media exposure. It is evident that STEM students consistently displayed greater support than non-STEM students. The highest discrepancy with non-STEM students was on the statement: "Using GE in agriculture can help solve food supply issues." [STEM M = 3.48 vs Non-STEM M = 2.69]. This trend reiterates the previous studies that state STEM-based courses that explore biotechnology principles and their applications in agriculture foster a more positive view of GE (Rathod & Hedaoo, 2022; Ramos et al., 2023). Chrispeels et al. (2019) reported similar results, noting that structured instructional interventions enhanced non-science majors' acceptance of GE applications in terms of food production as well.

Table 4 *Students' Attitudes Toward Genetic Engineering by Strand, Gender, and Media Exposure (N = 60)*

Statement	STEM (SD)	Non-STEM (SD)	Male (SD)	Female (SD)	Frequent Media Exposure (SD)	Occasional Media Exposure (SD)	Rare Media Exposure (SD)
1. Genetic engineering can help improve human health.	3.55 (0.85)	2.94 (0.80)	3.49 (0.88)	2.57 (0.90)	3.05 (0.84)	3.56 (0.83)	3.67 (0.81)
2. Using GE in agriculture can help solve food supply problems.	3.48 (0.88)	2.69 (0.82)	3.34 (0.91)	2.71 (0.92)	3.05 (0.85)	3.50 (0.84)	4.00 (0.80)
3. Genetic engineering may cause ethical concerns.	3.43 (0.90)	2.88 (0.78)	3.36 (0.86)	2.71 (0.89)	2.82 (0.86)	3.41 (0.82)	4.17 (0.79)
4. The risks of GE may outweigh its benefits.	3.32 (0.86)	2.75 (0.85)	3.21 (0.90)	2.86 (0.88)	3.00 (0.87)	3.34 (0.85)	4.00 (0.82)
5. I am willing to use medicine produced through genetic engineering.	3.18 (0.92)	2.81 (0.81)	3.09 (0.89)	3.00 (0.87)	2.91 (0.88)	3.31 (0.86)	3.33 (0.83)
6. Scientists should be allowed to edit human genes to prevent diseases.	3.18 (0.91)	3.00 (0.84)	3.15 (0.88)	3.00 (0.88)	2.91 (0.84)	3.19 (0.87)	3.17 (0.85)
7. GE may have adverse effects on the environment.	3.32 (0.94)	2.94 (0.86)	3.25 (0.87)	3.00 (0.90)	3.05 (0.85)	3.19 (0.83)	3.17 (0.84)
8. The government should strictly regulate genetic engineering.	3.39 (0.89)	3.00 (0.82)	3.36 (0.85)	2.71 (0.91)	3.05 (0.86)	3.34 (0.84)	3.17 (0.86)
9. I feel comfortable discussing GE topics with other people.	3.57 (0.87)	3.38 (0.79)	3.55 (0.88)	3.29 (0.92)	3.09 (0.87)	3.38 (0.85)	3.50 (0.82)
10. Genetic engineering topics should be included in Chemistry for Engineers.	3.55 (0.85)	2.94 (0.80)	3.45 (0.89)	2.86 (0.89)	3.32 (0.85)	3.75 (0.82)	3.00 (0.84)

Note: *Likert scale: 1 = **Strongly Disagree**, 5 = **Strongly Agree**. Higher means indicate stronger agreement.*

Gender differences existed too, with males typically scoring higher than females, especially on the statement "GE can help improve human health" (male M = 3.49, female M = 2.57). Students who believed they received occasional literacy engagement with science scored higher than those who reported regular or infrequent exposure. The highest mean score was "GE topics should be included in Chemistry for Engineers" (M=3.75). This also reiterates the Constructivist Learning Theory perspective (Piaget, 1972; Vygotsky, 1978) that short, important exposure is optimally engaging and may help grow curiosity and willingness to engage with unknowns. Regular or excessive exposure may promote saturation or skepticism about the unfamiliar, while little or no exposure gives zero opportunity for knowledge construction. Constructive, pleasing, and engaging science communication is reaffirmed in the DOST–NCBP (2024) program to integrate biotechnology awareness into several formats and forums within educational systems and communications media.

Overall, these findings indicate that GE attitudes are influenced by a mix of educational background, gender, and quality as opposed to quantity of science media experience. For teachers, this emphasizes the importance of focused approaches within Chemistry for Engineers to close attitudinal gaps, especially among non-STEM students and underrepresented groups.

3.5 Implications for Integrating Genetic Engineering in the Chemistry for Engineers Course

The integration of genetic engineering (GE) topics into the Chemistry for Engineers course can be determined by the trends from students' awareness, attitudes, and qualitative observations.

From the data on awareness (Table 3), most students identified widely known GE applications like DNA fingerprinting, cloning, and GMOs in farming. However, they were less likely to identify more recent developments such as CRISPR gene editing and the deployment of genetically modified bacteria for environmental remediation. This suggests the course could fill such gaps by teaching advanced GE technologies and their chemical underpinnings.

Attitude outcomes (Table 4) show strongly positive to moderately positive opinions of GE, especially regarding improving farm human health and productivity. A measure of variation by strand, gender, and science exposure was present, however. STEM students and science exposure regulars reported more positive attitudes, suggesting that exposure and existing knowledge are important for shaping perceptions. In planning courses, this implies that inclusive and accessible pedagogies must be used to attract students from various strands and levels of prior exposure.

Qualitative answers from each of the 60 students also place these findings in context. Students mentioned medical advantages (e.g., "It can cure diseases, make food and medicine better, improve crops"), agricultural advantages (e.g., "As a daughter of a farmer, higher crop yields are some advantages of applying genetic engineering"), and environmental advantages (e.g., "Applying engineered bacteria to clean environmental waste"). Concurrently, they also raised questions related to ethical concerns (e.g., "Is it right for everyone and will it be safe for everybody?"), health hazards (e.g., "It can add toxins into our body and trigger allergies if not used appropriately"), and ecological effects (e.g., "It could decrease biodiversity and have unexpected effects"). Several claimed limited familiarity with GE and asked elementary questions regarding its workings, safety, and regulation, highlighting knowledge gaps that a properly designed curriculum could fill.

Integrating GE into Chemistry for Engineers presents the chance to educate students in fundamental chemical and biochemical principles—such as molecular interactions, reaction mechanisms, and the chemistry of biomolecules and investigate ethical paradigms, safety procedures, and social effects. Applying case studies, debates, and GE's promises and risks helps students critically assess the benefits and dangers of GE.

In addition, directly relating GE applications to engineering problem-solving can render lessons more meaningful and engaging. Incorporating GE into Chemistry for Engineers can enhance scientific literacy, foster critical thinking, and prepare aspiring engineers to handle biotechnology responsibly, according to these awareness patterns, attitudes, and expressed interest.

4.0 Conclusion

The research findings indicated that first-year engineering students demonstrated various levels of awareness of genetic engineering (GE) applications, with students expressing a greater familiarity with medical and agricultural uses and less familiarity with newer technologies such as CRISPR. Overall, their attitudes toward the applications on GE were positive, although students had concerns about ethical considerations and environmental risks. Differences within all strands, gender, and media exposure suggested that background factors influenced perceptions. The findings highlight the importance of GE topics in the Chemistry for Engineers course, enhancing scientific literacy and interdisciplinary learning, and developing critical thinking skills for prospective engineers. Furthermore, linking the ethical and environmental considerations to the course discussions can enable students to develop a balanced view. Future research could examine awareness in other year levels, compare findings across institutions, and/or look at the value of GE modules in a classroom.

5.0 Contributions of Authors

The author confirms sole authorship of this study, with no co-authors or contributors. He wrote, revised, and finalized the manuscript for publication.

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The author declares no conflict of interest in the publication of this paper.

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