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Research Paper

Utilizing Internet Memes in Senior High School Biology to Improve Gen Z's Academic Achievement, Attitude, and Self-efficacy

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Generation Z learners' short attention span challenges educators to design engaging teaching methods that capture their interest. This quantitative study investigates the effect of memes, which are popular internet media, on non-STEM Gen Z high school students' academic achievement, attitude, and self-efficacy in biology. Two groups of Grade 11 participants (n=243) were taught cellular division and genetics lessons through two different approaches. The results demonstrate that the experimental group which was taught using meme-infused materials had statistically significantly higher post-test scores (21.46 ± 4.41 out of 30; independent *t*-test = 0.00) than students who were taught with materials with no memes (17.74 ± 4.00). Additionally, administering the modified Attitude Towards Science Inventory (ATSI) reveals that there is a statistically significant positive overall attitude in sciences in the experimental group (Mann-Whitney U test *p*-value = 0.00). Also, there is a statistically significant Biology Self-Efficacy (BSE) score (*p*-value = 0.00) for the group with meme-infused materials. This was consistent across all three BSE dimensions, namely confidence in methods in biology, generalization and analyzing data, and application of biological concepts and skills. Analysis of the specific descriptors posit that memes assisted in managing students' anxiety towards biology and boosted their confidence in their perceived capacity in the subject matter. This study contributes to the growing literature on possible pedagogical tools and strategies to cater to the new generation of learners.

Key words: *biology education, cellular division, Generation Z learners, genetics, memes, pedagogical innovation*

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INTRODUCTION

For the past decade or so, substantial research has been done on millennial learners and their expectations in the classroom. Millennial learners are eager to receive feedback on their performance and they also favor collaborative tasks and technology-infused learning (McGuire and Williams, 2002; Monaco and Martin, 2007; Alexander, 2012; Schwartz *et al*., 2018). As scholars and researchers have just gotten a good grasp of the kind of learners that millennials are, a new generation of students have already filled the classrooms, namely the Generation Z (Gen Z) learners.

Gen Z is characterized as the generation born between 1997 and 2010 (Twenge, 2018; Nicholas, 2020; Manzoni *et al*., 2021). They are true digital natives who were raised with smartphones and mobile tablets they could barely fit in their baby hands, unlike millennials who grew up immersed in analog and have lesser exposure to digital technology than Gen Z. Having this much technological exposure and digital know-how, Gen Z possesses the ability to retrieve and disseminate information instantaneously (Nicholas, 2020). This technological savviness of Gen Z learners from their younger years, however, poses some challenges during their years in formal education. Results of a recent study showed that Gen Z learners have an average attention span of eight (8) seconds, which is much shorter than 12 seconds of millennials (Nicholas, 2020). Attention span can be defined as the presence of mind required to establish a sincere interpersonal engagement (Subramanian, 2018).

One of the pop culture materials that speak to the young generations is memes (Fig. 1), which are media, mostly images with texts, that may contain cultural references and social representations (Reddy *et al*., 2020). Knobel and Lankshear (2007) posited that personalities, scenes from movies and shows, famous songs, and tag lines, or combination thereof, as typical elements of memes. While many memes use references from movies and television shows, their meaning on social media might not necessarily reflect their original meaning. Memes generally develop and solidify their meaning through repeated use in the public sphere, typically online (Reddy *et al*., 2020). Thus, while the origin may be from a local reference, its usage in(on?) the internet allows the global online community to develop a common new meaning to it.

For example, Fig. 1 features a personality from an online video game show or stream. On social media, the image of him blinking is being used to signify confusion or disbelief on the events unfolding. With the addition of text in Fig. 1., the meme is taken to mean that the supposed first cell that underwent mitosis was in disbelief because of the unprecedented event. Typically, in memes, a popular culture reference mixed with scientific or technical content adds a layer of humor among the younger audience.

The use of memes in natural and social sciences classes has shown that it enhances students' mastery of the topic (Moraes, 2021; Kyrpa *et al*., 2022) and their classroom engagement (Dongqiang *et al*., 2020; Byosiere *et al*., 2021; Soler *et al*. 2021). While literature suggests memes improve academic performance, further exploration is needed in understanding how memes affect attitude and self-efficacy in the subject matter.

Thus, this quantitative study aimed to explore the effect of using memes in biology lessons in the academic achievement, attitude, and self-efficacy of Grade 11 non-STEM students. With the natural inclination of STEM students to science subjects, such as biology, this study focused on students who belong to non-science track students in senior high school (pre-university) who are required to take a science course as part of the national curriculum. In particular, this study explored the approach in topics which the said demographics historically found difficult, namely cellular division and genetics. This paper aims to contribute to the growing literature on the innovative method of teaching using memes that is effective for Gen Z's.

MATERIALS AND METHODS

Participant recruitment

The participants of the study were 243 Grade 11 non-STEM students belonging to six sections of a private high school in the Philippines. Taught by the same teacher, the sections who were invited to participate in the study were non-STEM strand, in

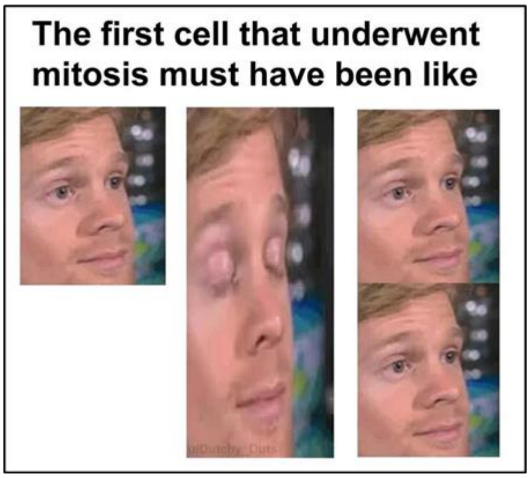

Figure 1: Sample meme using a social media reference
Image from https://i.redd.it/mjwlm7i22vj31.jpg.

order to guarantee that they were not given advanced science classes. Moreover, these sections were chosen because it was assumed that STEM section imbibes a general positive attitude and self-efficacy on the subject given their predisposition to the natural sciences and therefore would likely skew the results. Ethical clearance was secured from the Ateneo de Manila University's School of Science and Engineering Research Ethics Committee (SOSEREC_2023_010) and informed consent and assent were secured from the participants.

These classes were selected through cluster sampling by the fishbowl method. Three classes were randomly selected to be part of the experimental group while the other three classes comprised the control group. The control groups and the experimental groups were taught using the same materials with the difference that the materials for the experimental group was infused with memes.

Module development and validation

Materials developed in this study covered four topics, namely (1) Cellular Division, (2) DNA and RNA, (3) Central Dogma, and (4) Mendelian Genetics. These topics were chosen as these were among the least-learned competencies in science for non-STEM senior high schools from the previous school year. Two sets of parallel instructional materials were developed. One set contained memes in the instructor's slide deck and was used for the experimental groups, while the other set had no memes and were used for the control groups. The materials designed by us include lesson plans, PowerPoint Presentations (Appendix A), table of specifications, pre-test, post-test, and various activities. As part of the formative assessments, students were tasked to generate memes related to the topics.

The developed instructional materials were presented to four validators who were tasked to use the Department of Education (Philippines)'s official module evaluation standards. The validators of the module include two biology content experts, one English language expert, and one curriculum development expert. Additionally, two evaluators, namely one biology content expert and one anthropology expert, were invited to review the memes for scientific accuracy, relevance to the lesson, and appropriateness of the memes. This evaluation was done to ensure that the memes that were used in the module developed showed respect and cultural sensitivity, and do not violate, discriminate, or insult any individuals or cultural or ethnic groups. The materials developed in this study passed all the individual metric in the validation tools (data not presented in this study).

Incorporating memes in the lesson

Two types of memes were used in the module. The first set (Fig. 2) refers to the content-related memes whose role is to represent or repeat the discussion point in a humorous or creative way. The second set (Fig. 3) refers to icebreaker memes which do not necessarily deepen the lesson, but are inserted into the slide deck to deliberately pause briefly the discussion and/or to solicit feedback on whether the students still follow the lecture. Some memes were publicly available from the internet, while others were made using the available online templates from free websites that allow internet users to choose images and customize texts to generate their own memes such as Meme Generator (https://imgflip.com/memegenerator). It must be noted that all memes utilized in this study fall under Fair Use in the context of Philippine law, Section 185 of Republic Act No. 8293, which permits the use of copyrighted materials for purposes of education and research.

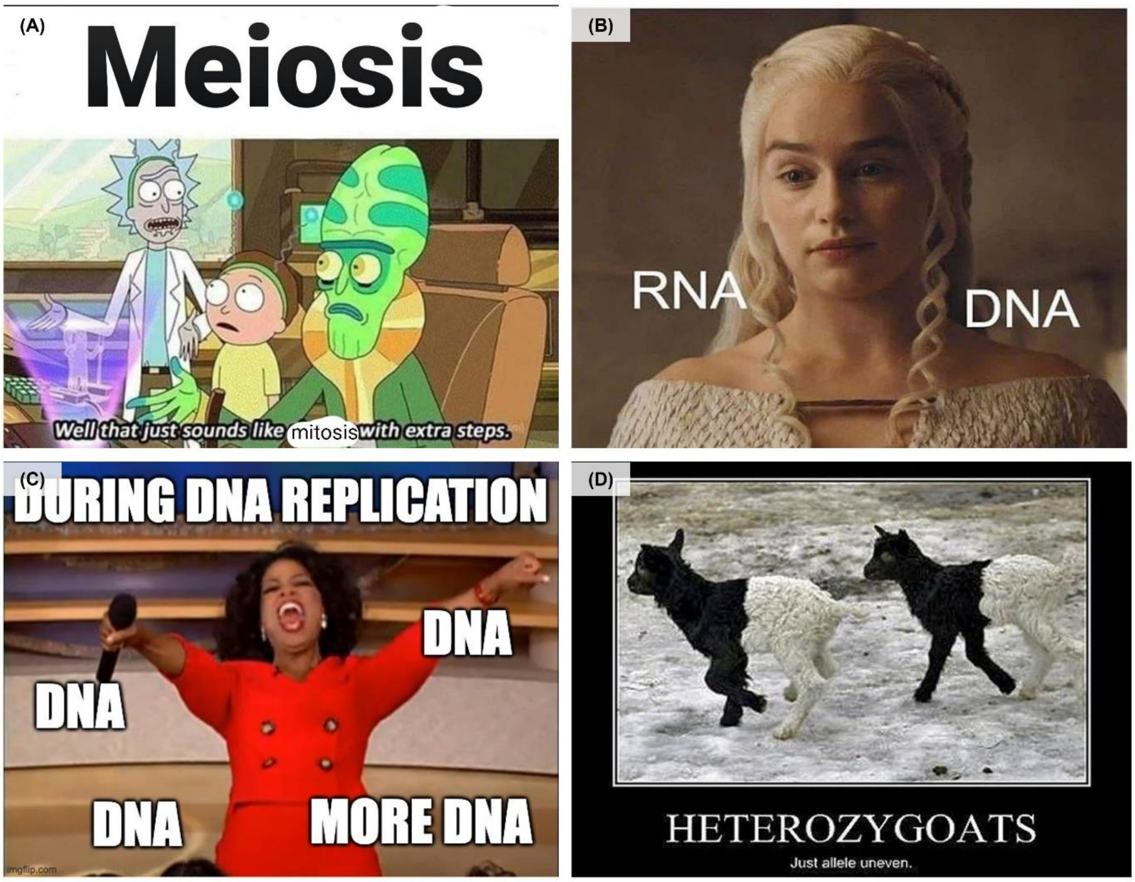

Figure 2: Sample content-related memes which are included in the slide deck
(A) Cellular Division, (B) DNA and RNA, (C) Central Dogma, and (D) Mendelian Genetics.
Images were taken/adapted from (A) https://i.redd.it/euods92jfg241.jpg, (B) https://pbs.twimg.com/media/EqjyXnwXEAAHYDk.jpg, (C) https://i.imgflip.com/80oy4o.jpg, (D) https://i.pinimg.com/474x/2d/58/02/2d5802fc1c7faca10b69beb14cfaea2f--nerd-jokes-nerd-humor.jpg

Figure 3: Sample icebreaker memes which were inserted to assess their understanding
(A) cellular division and (B) the overall lesson.
Images taken/adapted from (A) https://i.imgflip.com/80orsj.jpg, (B) https://giphy.com/gifs/youngertv-tv-land-tvland-l378wF1erD31LJm48 and https://giphy.com/gifs/laJU5IE8sU9AA

Most of the content-related memes and icebreaker memes were inserted within or after the informational slides about the lesson. For each of the four topics, an average of seven content-related memes and four icebreaker memes were included in the slide deck which ran for an average of 45 slides per topic.

Additionally, aside from the memes included in the module slide deck, one of the formative assessments employed in the lesson implementation entailed the participants from both the control and experimental groups to create their own content-related memes to demonstrate their understanding of Cellular Division and Genetics.

Assessing academic achievement in biology

To measure academic achievement, two parallel cognitive tests which were used as the module pre-test and module post-test were developed. Each test was designed to be a 30-item test which measured the understanding of the students of the topics presented at hand.

The scores in the pre-test were analyzed through an independent *t*-test to evaluate whether that the students in the control and experimental group have the same baseline knowledge in science. The scores in the post-test were analyzed in the same way to assess whether there was a significant difference after the module. Additionally, a paired *t*-test was used to analyze if there was a significant difference between the pre-test and post-test scores of the students in each group. For all these tests, if the *p*-value from the *t*-test is less than the 0.05 significance level, the null hypothesis is rejected.

Assessing attitude towards biology

To measure students' attitude toward biology, a modified and validated version of the Attitudes Toward Science Inventory (ATSI) originally developed by Gogolin and Swartz (1992) was administered to all participants after the module. Oducado's (2020) survey instrument validation rating scale (Appendix B) was used to validate the modified ATSI (Appendix C) to confirm whether the statements in the inventory reflect the Filipino learning context and were made to fit the lesson modules. It was presented to two validators who were chosen purposively based on their expertise on the content of biology curriculum, both of whom were the two biology content experts who also validated the modules. The modified ATSI is composed of 48-item Likert-type questions. Students answered each statement on a scale ranging from a value of 1 or strongly agree to a maximum value of 5 or strongly disagree. These statements were categorized into six constructs with eight items each: (1) perception of science, (2) anxiety toward science, (3) value of science in society, (4) self-concept in science, (5) enjoyment of science, and (6) motivation in science.

Since nominal level of measurement was used to measure the participants' attitude, the non-parametric Mann-Whitney *U* test was used to compare the results between the control and experimental groups. If the *p*-value is less than the significance level of 0.05, the null hypothesis is rejected. Mean scores of each statement in the ATSI were also computed and analyzed. The rating scales on the ATSI statements which were negatively stated were inverted in the data analysis to be consistent with the positively stated statements.

Assessing self-efficacy in biology

To assess students' self-efficacy in biology, a modified and validated version of the Biology Self-Efficacy (BSE) survey developed by Baldwin *et al*. (1999) was administered to all participants after the module. The modified BSE survey (Appendix D) consists of 23-item Likert-type questions which was also validated using Oducado's rating scale (Appendix B). Students evaluated the statements about their confidence in performing tasks related to the biology modules in Cellular Division and Genetics on a scale of 1 (totally confident) to 5 (not at all confident). The 23 statements were categorized into three dimensions: (1) methods of biology (statements 2, 3, 5, 6, 9, 12, 18, 19), (2) generalization to other biology/science courses and analyzing data (statements 8, 11, 14, 15, 17, 20, 21, 22, 23), and (3) application of biological concepts and skills (statements 1, 4, 7, 10, 13, 16). Data were analyzed similarly to ATSI results.

We conducted surveys on attitude and self-efficacy only at the end of the five-week lesson instruction in order to avoid students from experiencing survey fatigue. Hence, it would be valuable for future researchers to conduct surveys on these particular parameters before and after the intervention as a means to determine the accurate impact of memes on students' learning, especially if their lesson implementation and data gathering would span more than five weeks.

RESULTS

Students' reception of meme-infused materials

The participants from the control and experimental groups were tasked to create their own memes related to Cellular Division and Genetics. When they were asked about the task, they affirmed that creating their own memes related to their lesson was an effective strategy to enjoy the class. Additionally, some participants shared that their class had become more enticing and interesting since the teacher started incorporating memes in his slides. Other participants also claimed that memes helped them with lesson recall and retention.

Furthermore, the participants noted that the use of memes in the course was an effective method for them to review the material. This only proves that Hansen and Wilson (2023) were correct to assert that student-made memes encourage learners to think critically about the current topics they tackle in class. In relation to this, we made use of reverse image search to check whether the student-made memes were authentically produced by the students and were not simply downloaded from the internet. It has been revealed that a significant number of participants from the control group submitted already-existing downloaded memes while most of the participants from the experimental group generated their own memes. This implies that the participants from the experimental group were more inclined to create their own memes after being exposed to and taught using meme-infused teaching materials.

Effect on academic achievement

The participants from the experimental and control groups took a pre-test before the lessons on Cellular Division and Genetics were delivered and a parallel post-test after the module. While pre-test outcomes have a comparable mean of 13.29 and 13.09 for experimental and control group, respectively, the mean of the post-test scores of the experimental group is higher at 21.46 ± 4.41 than the control group at 17.74 ± 4.00 (Table 1).

The pre-test and post-test results of the control and experimental groups were treated using independent and paired t-test (Table 2). Independent t-test on the pre-test scores of the control and experimental groups (p-value = 0.69) confirmed that both groups had the same entry baseline knowledge on molecular genetics. While both experimental (p-value = 0.00) and control (p-value= 0.00) groups experienced an increase in academic achievement from pre-test to post-test, quantitative results demonstrate a statistically significant difference in the academic achieve-

Table1: Descriptive statistics results of the pre-test and post-test of the experimental and control groups

	Experimental group		**Control group**	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**
Mean ± SD	13.29 ± 2.57	21.46 ± 4.41	13.09 ± 3.37	17.74 ± 4.00
Min	8.33	11.67	8.33	9.67
Max	18.33	29.00	19.00	25.00
Mode	14.00	25.67	11.67	16.67
Median	13.33	21.67	12.00	17.67

Table 2: T-test results of the pre-test and post-test scores of the control and experimental groups

Null Hypothesis	***p*-value**
The median of differences between the control group's pre-test and experimental group's pre-test is equal to 0.	0.69
The median of differences between the control group's pre-test and post-test is equal to 0.	0.00
The median of differences between the experimental group's pre-test and post-test is equal to 0.	0.00
The median of differences between the control group's post-test and experimental group's post-test is equal to 0.	0.00

ment of students as supported by their post-test performance (*p*-value = 0.00) favoring the experimental group (mean = 21.46 vs. 17.74).

Effect on attitude toward biology

To assess attitude towards biology following the modules on Cellular Division and Genetics, students were asked to answer the modified ATSI after the module. Participants from both groups rated statements related to three constructs, namely perception of the science teacher (construct 1), value of science in society (construct 3), and enjoyment in science (construct 5), with a score interpreted as "Agree" (Table 3). This shows a positive attitude towards seeing the value of science in the real world and enjoying the lessons. Meanwhile, two constructs, namely having less anxiety toward science (construct 2) and witnessing self-concept in science (construct 4), recorded an "Agree" rating from the experimental group and an "Undecided" rating from the control group.

While Mann-Whitney *U* test on the attitude of the students toward biology revealed no statistically significant difference on each of the six ATSI constructs between the control and experimental groups, the overall ATSI scores showed that there is a statistically significant difference (*p*-value = 0.00) between the two groups (Table 4). This indicates that students taught with the aid of meme-infused materials had a more positive attitude towards the topic after the instruction compared to the students who were taught with materials lacking memes.

Effect on self-efficacy in biology

To assess self-efficacy of the population, the modified BSE was administered after the module. Results show that the experimental group felt "fairly confident" in all three dimensions, namely methods of biology (mean = 2.22), generalization to other biology/science courses and analyzing data (2.33), and application of biological skills (2.36), compared to the control group which rated

Table 3: Mean scores of the six constructs of the Attitudes Toward Science Inventory
(modified from Gogolin and Swartz, 1992)

	Experimental Group		Control Group	
ATSI Constructs	**Mean**	**Interpretation**	**Mean**	**Interpretation**
Construct 1: Having good perception of the science teacher	1.94	Agree	2.23	Agree
Construct 2: Having less anxiety toward science	2.27	Agree	2.57	Undecided
Construct 3: Seeing value of science in society	2.07	Agree	2.42	Agree
Construct 4: Witnessing self-concept in science	2.47	Agree	2.75	Undecided
Construct 5: Enjoying science	2.24	Agree	2.49	Agree
Construct 6: Forming sound motivation in science	2.53	Undecided	2.90	Undecided
TOTAL	13.52		15.36	

Table 4: Comparison of ATSI results using Mann-Whitney U test between the control and experimental groups

Null Hypothesis	*p*-value
Construct 1: The distribution of "Having good perception of the science teacher" is the same across categories of the control and experimental groups.	0.23
Construct 2: The distribution of "Having less anxiety toward science" is the same across categories of the control and experimental groups.	0.08
Construct 3: The distribution of "Seeing value of science in society" is the same across categories of the control and experimental groups.	0.20
Construct 4: The distribution of "Witnessing self-concept in science" is the same across categories of the control and experimental groups.	0.08
Construct 5: The distribution of "Enjoying science" is the same across categories of the control and experimental groups.	0.23
Construct 6: The distribution of "Forming sound motivation in science" is the same across categories of the control and experimental groups.	0.20
The distribution of the overall ATSI score is the same across categories of the control and experimental groups.	0.00

the dimensions as "somehow confident" (Table 5).

Moreover, the Mann-Whitney *U* test results for BSE (Table 6) revealed that there is a statistically significant difference on all three BSE dimensions (*p*-value = 0.00) favoring the experimental group.

DISCUSSION

Effect on academic achievement

These results confirm the positive effect of using memes in lectures in improving the academic achievement of students in science with statistically significant post-test scores (Table 2) between experimental group (mean = 21.46 ±

Table 5: Mean scores of the three dimensions of the Biology Self-Efficacy (Baldwin et al. 1999) survey

	Experimental Group		Control Group	
	Mean	**Interpretation**	**Mean**	**Interpretation**
Dimension 1: Methods of biology	2.22	Fairly Confident	2.77	Somewhat Confident
Dimension 2: Generalization to other biology/science courses and analyzing data	2.33	Fairly Confident	2.89	Somewhat Confident
Dimension 3: Application of biological concepts and skills	2.36	Fairly Confident	2.82	Somewhat Confident

Table 6: Comparison of BSE results using Mann-Whitney U Test between the control and experimental groups

Null Hypothesis	*p*-value
Dimension 1: The distribution of "methods of biology" is the same across categories of the control and experimental groups.	0.00
Dimension 2: The distribution of "generalization to other biology/science courses and analyzing data" is the same across categories of the control and experimental groups.	0.00
Dimension 3: The distribution of "application of biological concepts and skills" is the same across categories of the control and experimental groups.	0.00
The distribution of the overall BSE score is the same across categories of the control and experimental groups.	0.00

4.41) and control group (17.74 ± 4.00). Affirming the findings presented here, improvement of academic performance using memes was studied in various fields such as English for non-native speakers (Purnama, 2017), political science (Wells, 2018), philology (Kyrpa *et al*., 2022), and mathematics (Bini, 2021), as well as in natural science (Riser *et al*., 2020; Marymee, 2021; Moraes, 2021).

Memes were deemed to be helpful in improving students' mastery of the topic. For example, in the context of an introductory organic chemistry course, Marymee (2021) reported that the integration of topic-related memes in assessments improved students' understanding and retention of the material, and higher assessment marks. Moreover, whether used by the teachers or made by the students, memes were identified to pave the way for the development of critical thinking and scientific literacy of learners (Moraes, 2021; Riser *et al*., 2022), especially in the field of natural sciences such as biology, chemistry, and physics (Lopes, 2023).

Furthermore, the results of this study suggest that the students taught with meme-infused materials were able to understand and retain scientific information better than their counterparts from the control group. These results support the idea of Moraes (2021) which posited that memes are vital tools in the dissemination of scientific information due to the interesting appeal of the images to the younger generations.

Effect on attitude toward biology

The overall ATSI score (Table 3) of the experimental group (total = 13.52) is statistically significant compared to the control group (total = 15.36). This signifies that the experimental group composed of non-STEM students has a more positive attitude towards the biology following the intervention compared to the control group. Koballa and Glynn (2007) and Schruba (2008) posited that the strategies the teacher uses in class heavily influence students' attitude towards the subject. A learning environment with varied teacher strategies and unconventional student tasks supplemented by student engagement fosters a strong positive attitude toward science among the students (Myers and Fouts, 1992; Ershler and Stabile, 2015; Brown, 2020; Cromby, 2022). Similar trend was also noted when memes were used in literature and language classes (Dongqiang *et al*., 2020; Adha et al., 2023), though not in a political science class (Galipeau, 2023).

One possible reason for the improvement in the attitude towards biology is the memes as being means to facilitate active learning. Teaching strategies and student activities that promote active learning are effective in establishing a positive attitude toward science subject matter (Koballa and Glynn 2007; Freeman *et al*., 2014; Cooper *et al*., 2018). Utilizing memes in lectures and meme-making itself can be described as entertaining because they break the class monotony. Moreover, the novelty and unconventionality of memes in lectures might be deemed effective in piquing student interest, and thus improving their attitude toward biology.

Moreover, the experimental group rated two constructs, namely having less anxiety toward science (construct 2; 2.27 vs. 2.57) and witnessing self-concept in science (construct 4; 2.47 vs. 2.75), as "Agree" compared to the "Undecided" rating from the control group (Table 3). In the classroom context, Covington (1992) described anxiety as a reaction to the possibility of failure which can be overwhelming for students, especially when they exert extra effort into a task because they feel incompetent. Such feeling might be natural for students chartering an unfamiliar topic (Mallow *et al*., 2010; Bryant *et al*., 2012), which is akin to non-STEM students taking on a pre-university science class.

Meanwhile, science self-concept is defined as one's perception regarding their general capability in science (Sarsani, 2007; Jansen *et al*., 2014, 2015). While this study treated academic achievement and attitude toward science as separate variables, several studies also reveal that a high level of self-concept in science is a positive predictor of academic achievement in science (Jansen *et al*., 2014; Zhang *et al*., 2021). Thus, the introduction of memes, as shown in this study, was able to alleviate such anxious feelings towards biology and was able to help build the students' perception regarding their ability toward the subject matter.

Effect on self-efficacy in biology

This study has shown that the experimental group has a higher self-efficacy score that the control group (p-value = 0.00) across three dimensions (Tables 5, 6), namely methods of biology (mean = 2.22 vs. 2.77), generalization to other biology/science courses and analyzing data (2.33 vs. 2.89), and application of biological concepts and skills (2.36 vs. 2.82). Across these dimensions, the experimental group rated the statements as "Fairly confident" compared to the control group which gave a "Somewhat confident" rating. Previous research shows that higher self-efficacy is related to lower anxiety toward science (Britner, 2008; Griggs *et al*., 2013; Ardasheva *et al*., 2018). The experimental group experienced lower levels of anxiety toward science (mean = 2.27 vs. 2.57, Table 3) and greater levels of self-efficacy in biology (p-value = 0.00, Table 6) compared to the control group. The outcome indicates that the students from the experimental group had greater confidence in all three BSE dimensions compared to their counterparts from the control group after the lesson implementation with the use of meme-infused instructional materials. With memes embedded in the teacher lectures, our findings show that students felt more confident in understanding the concepts well, performing tasks better, and being successful in the course.

Improving self-efficacy in the classroom is important as it contributes to learning. Similar to the case of attitude towards science, while academic achievement and self-efficacy were treated as separate variables in this study, self-efficacy in science can be a strong predictor of learners' academic achievement (Tuan *et al*., 2005; Usher and Pajares, 2008; Ahmad and Safaria, 2013; Honicke and Broadbent, 2016). Students with greater self-efficacy in science are more confident in their abilities, more eager to accomplish science-related activities, and more determined in completing challenging science tasks (Baldwin *et al*., 1999; Britner and Pajares, 2006). In this study, the experimental group demonstrated a greater sense of self-efficacy as well as better academic achievement in biology compared to the control group. These findings suggest that the use of meme-infused materials is effective in improving students' self-efficacy and consequently, their academic achievement.

CONCLUSIONS

This study has shown that using memes in discussing Cellular Division and Genetics topics to non-STEM pre-university students improves their academic performance, attitudes towards science, and self-efficacy. This suggests that innovative teaching strategies that utilize materials which Gen Z's find relatable and accessible are beneficial for student's learning in biology. With the comparison of pre-test and post-test scores, there is a statistically significant difference in the academic achievement between the group which received meme-infused materials and the group which did not encounter the meme-centered intervention. Thus, the use of memes in lectures aid in the improvement of learning and academic performance of non-STEM Gen Z students, especially on the science concepts and competencies commonly perceived as complex and challenging by students.

Moreover, through comparison of ATSI and BSE scores, it was identified that the use of memes in tackling a difficult topic and the creation of memes by the students helped the participants develop a positive attitude toward biology and higher sense of self-efficacy in biology. Scanning the particular indicators, such effect was generated by helping the students manage their anxiety towards biology and by boosting their confidence in their capacity in the subject matter.

By examining the effect of internet memes on high school Gen Z students' academic achievement, attitude and self-efficacy in science, teachers can identify potential tools, instructional materials, and pedagogical strategies that they may utilize to better cater to this new generation of learners. High school science educators may benefit from the findings of this study by designing their lectures, assessments, and classroom management techniques with humorous elements like memes to improve student interest and success in class. Future explorations on the use of meme in biology education can focus on examining its impact on student motivation, belief, and learner engagement among others. Further studies can also delve into dissecting the effect of the timing of usage and nature of memes used in the classroom.

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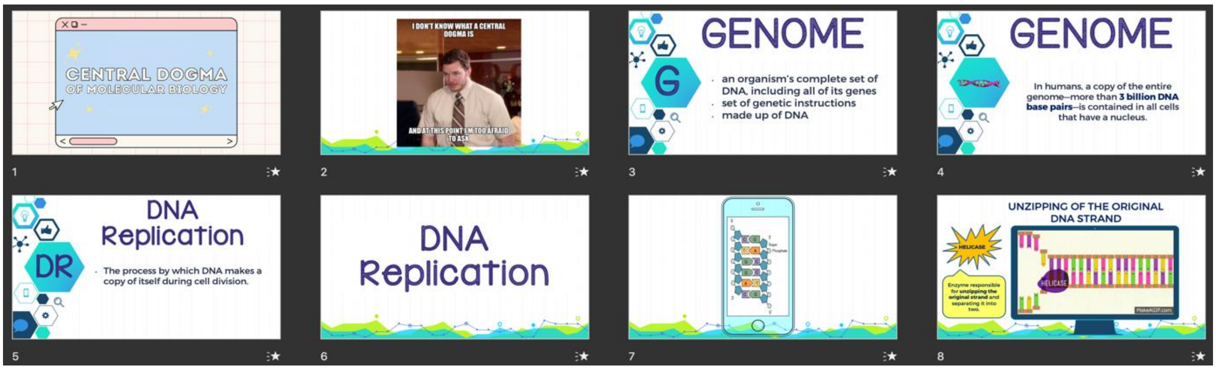
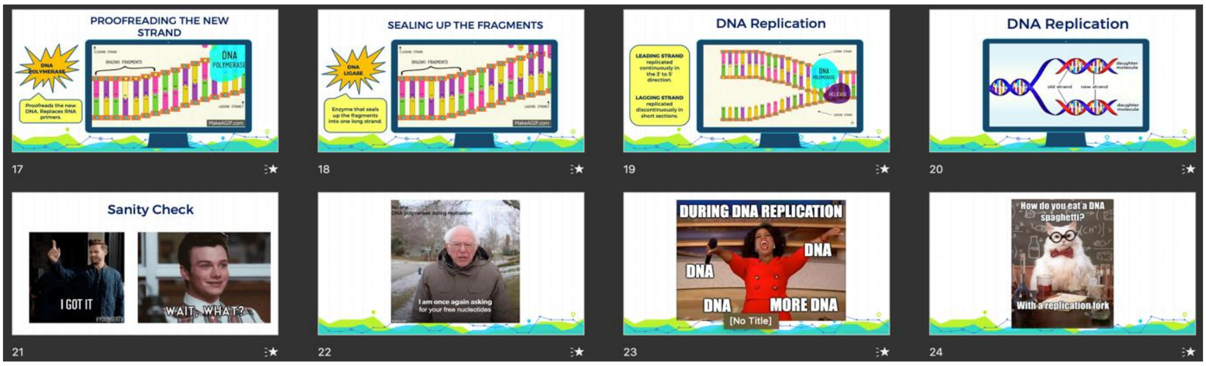
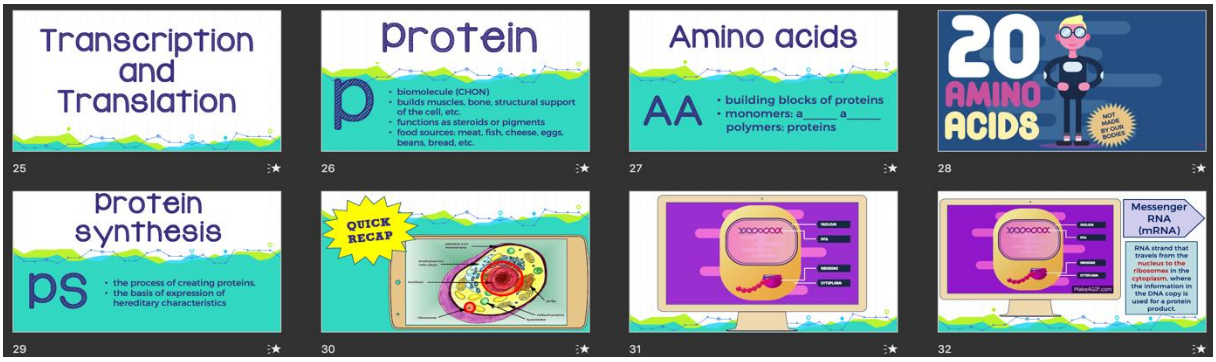
APPENDICES

Appendix A: Teacher's slide deck for a sample module



Slides 9–16: omitted





Slide 33–40: omitted

Appendix B: Validation tool for modified ATSI and BSE (Oducado, 2020)

Instruction: Please indicate your degree of agreement or disagreement on the statements provided below by encircling the number which corresponds to your best to your judgment.

1 – Strongly Disagree **2** – Disagree **3** – Undecided **4** – Agree **5** – Strongly Agree

1.	The items in the instrument are relevant to answer the objectives of the study.	1	2	3	4	5
2.	The items in the instrument can obtain depth to constructs being measured.	1	2	3	4	5
3.	The instrument has an appropriate sample of items for the construct being measured.	1	2	3	4	5
4.	The items and their alternatives are neither too narrow nor limited in its content.	1	2	3	4	5
5.	The items in the instrument are stated clearly.	1	2	3	4	5
6.	The items on the instrument can elicit responses which are stable, definite, consistent and not conflicting.	1	2	3	4	5
7.	The terms adapted in the scale in the scale are culturally appropriate.	1	2	3	4	5
8.	The layout or format of the instrument is technically sound.	1	2	3	4	5
9.	The responses on the scale show a reasonable range of variation.	1	2	3	4	5
10.	The instrument is not too short or long enough that the participants will be able to answer it within a given time.	1	2	3	4	5
11.	The instrument is interesting such that participants will be induced to respond to it and accomplish it fully.	1	2	3	4	5
12.	The instrument as a whole could answer the basic purpose for which it is designed.	1	2	3	4	5
13.	The instrument is culturally acceptable when administered in the local setting.	1	2	3	4	5
	TOTAL					

Comments/Suggestions:

Evaluator's name: ________________________
Evaluator's signature: ________________________
Date: ______________________

Appendix C: Attitudes Towards Science Instrument (ATSI), modified from Gogolin & Swartz (1992)

Perception of the science teacher (construct 1)

5. Earth and Life Science teachers show little interest in their students.
17. Earth and Life Science teachers make science interesting for me.
21. Science teachers present materials in a way that I understand.
27. Science teachers know when I am having trouble with my assignments.
31. Earth and Life Science teachers do not seem to enjoy teaching science.
40. Science teachers are willing to give me individual help.
44. Earth and Life Science teachers know a lot about science.
46. Science teachers do not like students to ask questions.

Anxiety toward science (construct 2)

7. I feel at ease in an Earth and Life Science class.
11. When I hear the word “science”, I have a feeling of dislike.
20. I feel tense or upset when someone talks to me about Earth and Life Science.
25. It does not disturb or upset me to do written works and performance tasks in Earth and Life Science.
34. Working with science upsets me.
36. It makes me nervous to even think about doing science.
39. It scares me to have to take a science class, especially since I am in a non-STEM strand.
43. I have a good feeling toward science.

Value of science in society (construct 3)

1. Earth and Life Science is useful for solving the problems of everyday life.
9. There is little need for Earth and Life Science in most of today’s jobs.
12. Most people should study some Earth and Life Science.
15. Earth and Life Science is helpful in understanding today’s world.
23. Science is of great importance to our country’s development.
24. It is important to know science in order to get a good job.
33. You can get along perfectly well in everyday life without science.
38. Most of the ideas in Earth and Life Science are not very useful.

Self-concept in science (construct 4)

4. I do not do very well in Earth and Life Science.
10. Earth and Life Science is easy for me.
16. I usually understand what we are talking about in Earth and Life Science.
19. No matter how hard I try, I cannot understand Earth and Life Science.
22. I often think, “I cannot do this,” when a Earth and Life Science assignment seems hard.
30. I am good at working science labs and hands-on activities.
35. I remember most of the things I learned in science class when I was in junior high.
48. If I do not see how to do an Earth and Life Science assignment right away, I never get it.

Enjoyment in science (construct 5)

2. Earth and Life Science is something that I enjoy very much.
6. Doing science labs or performance tasks is fun.

13. I would like to spend less time in school studying Earth and Life Science.
18. I do not like anything about Earth and Life Science.
26. I would like a job that does not use any science.
28. I enjoy talking to other people about science.
29. I enjoy watching a science program/video on television or online.
45. Earth and Life Science is one of my favorite subjects.

Motivation in science (construct 6)

3. I like the easy Earth and Life Science written works and performance tasks best.
8. I would like to do some extra or unassigned reading in Earth and Life Science.
14. Sometimes I read ahead in our Earth and Life Science modules.
32. I like the challenge of science written works and performance tasks.
37. I would rather be told scientific facts than find them out from experiments and performance tasks.
41. The only reason I am taking Earth and Life Science is because I have to.
42. It is important to me to understand the work I do in Earth and Life Science class.
47. I have a real desire to learn Earth and Life Science.

Appendix D: Biology Self-efficacy (BSE) instrument, modified from Baldwin et al. (1999)

Methods of biology (dimension 1)

2. How confident are you that you could critique a lesson summary written by another student?
3. How confident are you that you could create an accurate meme about Cellular Division and Genetics?
5. How confident are you that you could learn about an Earth and Life Science lesson and feel sure about creating your own meme about it?
6. How confident are you that you could write about the mitotic and meiotic stages?
9. How confident are you that you could write about the process of creating monohybrid and dihybrid crosses?
12. How confident are you that you could write about DNA and RNA?
18. How confident are you that you could tutor another student on Cellular Division and Genetics?
19. How confident are you that you could understand a mitotic/meiotic diagram in a biology textbook (i.e. determine the stages)?

Generalization to other biology/science courses and analyzing data (dimension 2)

8. How confident are you that you will be successful in this course?
11. How confident are you that you will be successful in another biology course?
14. How confident are you that you would be successful in an ecology course?
15. How confident are you that you could analyze a monohybrid/dihybrid cross (i.e., look at the genotypes and phenotypes)?
17. How confident are you that you would be successful in a human physiology course?
20. How confident are you that you could tutor another student for this Earth and Life Science course?

21. How confident are you that you could ask a meaningful question that could be answered experimentally/through a hands-on activity?
22. How confident are you that you could explain something that you learned in this Earth and Life Science course to another person?
23. How confident are you that you could use a scientific approach to solve a problem at home?

Application of biological concepts and skills (dimension 3)

1. How confident are you that after being taught lessons in Cellular Division and Genetics, you could write a summary of the main points of the lessons?
4. How confident are you that after being taught lessons in Cellular Division and Genetics, you could explain its main ideas to another person?
7. How confident are you that after watching an informative video dealing with some aspect of biology, you could write a summary of its main points?
10. How confident are you that after watching an informative video dealing with some aspect of biology, you could explain its main ideas to another person?
13. How confident are you that after listening to a public lecture regarding some biology topic, you could write a summary of its main points?
16. How confident are you that after listening to a public lecture regarding some biology topic, you could explain its main ideas to another person?