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Online, Offline, Flexible: Instructional Delivery Preferences of Pre-service Teachers in College Genetics and Its Implications for Curriculum, Instruction and Assessment

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Abstract

Learning curricula are designed to be needs-focused but are expected to be learner-friendly nonetheless. This study aimed to measure the level of instructional delivery preferences of undergraduate students in an introductory Genetics course (online, offline, flexible) and determined the influence of gender, year level, and post-secondary track. Using a descriptive survey approach, a list of genetics undergraduate topics were prepared based on various sources including university syllabi, textbooks, and other instructional materials. The questionnaire was administered digitally to undergraduate students in one large public university in mid-2021. Findings report that a genetics undergraduate course is preferred to be delivered 'Highly Online' with a few topics agreed upon by respondents as 'Flexible'. On the contrary, teacher-experts prefer the course to be delivered in a 'Flexible Manner' with most of the topics to be delivered 'Highly Offline'. Further, the student-respondents in any year level did not have any significant difference in their instructional delivery preferences in the listed topics, while a few topics' instructional delivery preferences were viewed differently statistically by female respondents and those who graduated from non-STEM tracks in senior high school favoring such topics with 'Highly Online'. Implications are drawn from the findings to better understand its influence to undergraduate curriculum, college instruction, and student learning assessment.

Keywords: Flexible Learning; Genetics; Higher Education; Instructional Delivery; Undergraduate Studies

INTRODUCTION

Over the past 20 years, the focus of national efforts to develop and improve K-12 science education in the United States has ranged from curriculum and professional development of teachers to the adoption of science standards and high-stakes testing, as Dougherty (2009) noted. As he aptly stated, the underperformance of students (in the United States and for the rest of the world) is particularly worrisome given the accelerating need for scientists and engineers in our increasingly technology-driven economy. He emphasized that a scientifically literate public is essential if citizens are to engage effectively with policymakers on issues of scientific importance. However, despite curricular improvements over the years, it appears that the Philippines has a lot of catching up to do in scientific literacy with respect to the world as revealed in the results of PISA 2023. Therefore, not only are recalibrations in the basic education sector necessary but also in the undergraduate preparation of teachers.

One of the fields of science, biology to be more specific, that promises potentials for the improvement of human life but in itself entails ethical, legal, and social issues is genetics. Simply stated, genetics is the study of biologically inherited traits. Each species of living organism is united by a common set of inherited traits, observable characteristics that set it apart from all other species of organisms (Hartl & Jones, 2006). By understanding these principles of inheritance, students, and by extension, the citizens, will be able to evaluate claims that may stem from hearsay, misconception, or superstition, and make informed decisions regarding health and agriculture. For example, birth defects, which may be of genetic origin, have been in the top 10 causes of infant mortality in the Philippines (DOH, 2014). This highlights the need for genetic counselors, and evidently, there is a dearth of them in the country (Abad et al., 2023). As Silao (2017) puts it, genetics is pushing the boundaries of medicine forward. In fact, the Philippine Genome Center was established a decade ago to catalyze research in genetics for medical, agricultural, and forensic purposes among others. Thus, a strong science education, in this case, foundation in genetics in basic education is necessary to attract more men and women into careers in genetics.

Unfortunately, learning genetics is challenging at the high school (Machova & Ehler, 2023; Adelana, Akinsulare, Ajose, & Ishola, 2023; Mussard & Rice, 2022; Grace, 2021) and undergraduate levels (Smith & Wood, 2016). Several studies have shown gaps in understanding concepts in genetics. More recently, Machova and Ehler (2023) have shown that participating 8th and 9th graders have a superficial understanding of inheritance, which may have led to misconceptions and difficulties in establishing relationships among concepts in genetics and other areas of biology. Interestingly, many of the misconceptions are similar to those observed in other European nations. Two common roots that researchers have attributed to these problems are more teacher-centered methods (Machova & Ehler, 2023; Grace, 2021; Smith & Wood, 2016) and lack of time (Machova & Ehler, 2023; Grade, 2021). However, Bowling et al (2008) observed that in a college setting, the time spent on learning genetics did not significantly affect students' knowledge gains. Further, concepts in genetics are abstract and require specialized vocabulary, which contribute to the difficulty learning these (Mussard & Reiss, 2022).

Research on the teaching of college genetics reveals a preference for a more research-oriented approach, with a focus on cultivating students' research ability (Xing, 2016). However, this is often hindered by time constraints and curriculum crowding (Nicol, 2002). Despite these challenges, there is a consensus among educators and practitioners on the importance of genetics in health care and the need for its inclusion in undergraduate programs (Nicol, 2002; Young, 1984). The evolution of genetics teaching has also been noted, with a shift towards broader content and more active learning approaches (Smith, 2016).

The Philippine's Commission on Higher Education in the issuance of policies, standards and guidelines for the Bachelor of Secondary Education is guided by an outcomes-based quality assurance system as advocated under CMO No. 46, s. 2012. Further, under CMO No. 75, s.

2017, Education students who major in 'Sciences' are expected to possess the following learning outcomes: (a) demonstrate deep understanding of scientific concepts and principles, (b) apply scientific inquiry in teaching and learning, and (c) utilize effective science teaching and assessment methods. Furthermore, this Memorandum contained Genetics as one of the major courses to be taken by students under the Bachelor of Secondary Education, Major in Science program, with both a 3-unit lecture and 1-unit laboratory. Genetics is described, for the lecture, as a course which deals with the principles of heredity and variation, its application in plant and animal breeding, and problems involved in it. It also involved biometrical treatment of qualitative and quantitative characters of both plants and animals. For the laboratory, Genetics as a course deal with exercises on chromosomal basis of inheritance, structure of genetic material and Mendelian and Non-Mendelian inheritance.

Curriculum studies in Science Education are imperative to further developing the scientific mind of learners to keep pace with changes in the society. Camara (2020a) believes that no curriculum exists in isolation, whereby each curriculum is designed to be an input to another output, and observed that the interplay of curricula in the trifocal system of education in the Philippines only becomes ideal when alignment is checked at crucial checkpoints, i.e. the K to 12 Basic Education Curriculum, and for higher education institutions, the revised policies, standards and guidelines of the Based Programs as contained in CMO No. 75, s. 2017. In terms of alignment of lessons, Camara (2020b) found that Filipino K to 12 graduates believe that the K to 12 subjects they took in senior high school are aligned with their college courses (engineering), though they did not believe that the Spiral Progression approach helped them master science concepts in college. Therefore, aside from a continual evaluation and refinement of curricula in the basic education sector, TEIs may implement instruction responsive to the needs of science education majors not only to help them succeed in a genetics course but also adequately prepare them to teach accurate and well-integrated content to high school students in the future. Since the pandemic closed universities in March 2020, these have shifted abruptly to online learning. Pre-service science teachers, who play a crucial role in promoting scientific literacy, may face difficulties in understanding genetics concepts and require effective learning approaches (Altunoglu, 2015). Therefore, it is important to consider the perspectives of pre-service teachers in designing effective and engaging genetics education during the pandemic.

METHOD

This study used a survey method. The questionnaire was administered digitally to undergraduate students in mid-2021. The respondents of the data were the undergraduate students of one state university located in Pangasinan, Philippines. The sample consisted of eighty-two (82) students segmented through year level as 1st year (25.6%), 2nd year (37.8%), and 3rd year (35.4%). For purposes of analysis, the 1.2% (1 of 82) participation of an irregular student was excluded in the presentation but not in the analysis as this is an extreme value that will automatically reject statistical computation. During the time of data-collection, 61.0% of the respondents were yet to enroll in a genetics class in the succeeding year. It should be noted that during the writing of this copy (2023), those who were 'enrolled students' have already graduated and passed the licensure examination for teachers with their cohorts registering a 100% successful passing. To triangulate the responses from the students, the instrument was also sent to five (5) science experts during the 1st quarter of 2022. Two of these experts are graduates of Biology and are holders of a PhD in Science Education, one is specialized in science and has been involved in school curriculum assessment, and two are science major professors in a public state university and a private higher education institution in the Philippines, both in Region I, Philippines.

Instrumentation, Collection and Data Analysis

The main instrument used in the study is a 5-point Likert scale survey-questionnaire on selected profile variables of the respondents as well as a list of genetics topics *(n=48)* for an undergraduate course in the Philippine context which registered a 'Very Highly Valid' score from experts. The instrument was administered digitally via email, FB messenger, and MS Teams from April to May, 2021, and was closed on May 12, 2021. Data were collected via Google Sheets. The data were pre-coded, tabulated, and converted into a readable file for SPSS v20 analysis. Data were subjected to simple descriptive statistics. A Syllabus for Teaching Genetics based on the findings was developed by the researcher and was tested for its acceptability. However, the full results for the development and acceptability are not included in this report since it is implemented under a different BOR Resolution for the year 2023.

Identification of Topics for Survey-Questionnaire

The researcher surveyed the Table of Contents and Sample Chapters of at least five (5) Filipino-authored textbooks on Genetics available during the time of study (December 2020) considering topics which were overlapping and/or emphasized which is similar with the initial methodology of Camara (2018) in developing the Research Curriculum Competency Checklists for Special Science students. It was the researcher's belief that overlapping topics and those with emphasis by textbook authors are indispensable contents of a list of genetics topics. Further, course syllabi proposed for use in the subject in the study locale were consulted as well. Majority of the topics were taken from existing syllabi for the subject during the time of data-collection (December 2020) which has not been modified up to this time (December 2023).

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RESULTS AND DISCUSSIONS

Profile of the Respondents *(n=82)*

Table 1. Profile of the Respondents (n=82)

Profile	Category	f	%
Gender	Male	24	29.3
	Female	57	69.5
	Prefer Not to Say	1	1.2
Age	18-19	29	35.4
	20-21	45	54.9
	22 above	8	9.8
Curriculum Year	1st	21	25.6
	2nd	31	37.8
	3rd	29	35.4
	Irregular	1	1.2
STEM Graduate	Yes	19	23.2
	No	63	76.8
Course Taken	Yes	4	4.9
	No	78	95.1
Course Enrolled	Yes	32	39
	No	50	61
Gadgets Used	Laptop	8	9.8
	Mobile Phone	74	90.2
Delivery Mode	Fully Offline	24	29.3
	Partially Offline/Partially Online	55	67.1
	Fully Online	3	3.7
ONLINE Pass	Yes	68	84.1
	No	13	15.9
OFFLINE Pass	Yes	39	47.6
	No	43	52.4
PARTIAL Pass	Yes	78	95.1
	No	4	4.9
	Total	82	100

Table 1 shows that 69.5% of the respondents are female while 29.3% are male. In terms of age, most of them are either 20 or 21 years old (54.9%) while some are aged 18 or 19 years old (35.4%). Majority of the respondents are in their 3rd year (37.8%) followed by 2nd year students (35.4%). A little more than three-fourths of the respondents are non-STEM graduates (76.8%) while only 23.2.% are STEM graduates. Also, results showed that almost all of the respondents have not yet taken Genetics (95.1%). In terms of subject enrollment, a little more than a third of the respondents are currently enrolled (39.0%) upon data collection while the majority were not (61%). In terms of gadgets used in online learning, the majority of the students used cell phones (90.2%) while few used laptops (9.8%).

Further, when asked about preferred delivery mode of learning for genetics more than a half of the respondents chose partially offline/partially online (67.1%), while few chose fully offline (29%) and fully online (3.8%). Furthermore, in terms of passing the subject based on the delivery modes, less than 50% (47.6%) of the respondents thought a fully offline delivery mode will help them pass the course. In contrast, more than 75% of them believed that having a fully online or a partially online/offline mode will allow them to earn a passing grade. It is important to note, however, that 95.1% of the respondents perceived that learning in a combined online and offline environment will result in a passing grade. Partially Offline/Partially Online obtained the highest number of respondents who believe they will pass the subject among the stated delivery modes of learning (95.1%).

Instructional Delivery Preferences in Undergraduate Genetics

The student-respondents (n=82) were asked to rate the level of their instructional preference of genetics topics as either online, offline (highly or very highly), or 'Flexible.' When they select this 'Flexible' option, they consider the topic to be delivered either in an offline or online mode, whichever is applicable at the moment of the teacher's instruction. Based on Table 2, it appears that 16.67% (8 of 48) of the topics are considered 'Flexible' by the respondents, and these topics are found in the first chapter of Genetics. This is understandable because any first chapter of any undergraduate course contains topics which are basic in nature or are introductory which does not have to be complex. Further, Table 2 reveals that 83.33% (40 of 48) of the topics are considered to be delivered 'Highly Online'. This is supported by the study of Zhou (2020) that online teaching has its unique features, so it is not wonder why students would prefer it mostly.

These topics are found after the first chapter until the last chapter with the topic 'Oncogene' *(M=2.04;sd=0.99)* receiving the lowest mean which, in the scale of interpretation, is the topic considered to be most 'highly online'. The standard deviation of 0.99 shows that the answers of the students in any curriculum level are similar or less spread out. In summary, however, the whole genetics topical list (n=48) is preferred to be delivered 'Highly Online' *(M=2.33;sd=1.00)*. This result is understandable because a course in applied sciences including genetics is non-self-explanatory and guidance from the teacher is necessary. Genetics courses tend to be difficult since these attempt to explain events at the molecular level that may involve several players with various interactions. Genetics is an abstract course. These findings differ with the perception of the teacher-respondents (n=5) which prefers that a genetics undergraduate course could be delivered in a 'flexible manner' (see Table 2).

Table 2. Instructional Delivery Mean Preferences and Correlates

No	Topics in Undergraduate Genetics	STUDENTS			TEACHERS		
		M	sd	DE	M	sd	DE
1	Definition and Importance of Genetics	2.95	1.07	F	3.83	1.60	Hf
2	History of Genetics	2.95	1.09	F	4.00	1.55	Hf
3	Principles of Inheritance	2.71	1.04	F	3.83	0.75	Hf
4	Basic Concept of Genetics	2.93	1.10	F	4.00	0.89	Hf
5	Significance of Genetics in Society	2.89	1.12	F	4.33	0.89	VHf
6	Characteristics of Useful Expt Organisms	2.38	1.04	Hn	4.17	0.98	Hf
7	Basic Genetics Terms	2.79	1.09	F	4.17	0.98	Hf
8	Cell Structure	2.63	1.10	F	3.84	1.32	Hf
9	Cell Division	2.49	1.11	Hn	3.50	1.05	Hf
10	Life Cycle	2.70	1.16	F	3.44	1.03	Hf
11	Chromosome Type	2.55	1.09	Hn	3.50	1.05	Hf
12	Chromosome Morphology	2.11	0.92	Hn	3.50	1.05	Hf
13	Chemical Composition of the Chromosome	2.17	0.91	Hn	3.17	0.98	Hf
14	DNA Structure and Composition	2.49	1.10	Hn	3.33	1.03	F
15	RNA Structure and Composition	2.56	1.17	Hn	3.33	1.03	F
16	DNA Replication	2.39	1.09	Hn	3.17	0.98	F
17	Protein Synthesis	2.30	0.95	Hn	3.00	0.89	F
18	The Genetic Code	2.26	1.11	Hn	3.00	1.10	F
19	Monohybrid Inheritance	2.18	1.03	Hn	3.17	0.75	F
20	Dihybrid Inheritance	2.12	1.02	Hn	3.17	0.75	F
21	Multiple Alleles	2.22	1.03	Hn	3.17	0.75	F
22	Sex-linked traits	2.24	0.98	Hn	3.17	0.75	F
23	Environmental Influence on Gene Expression	2.30	1.01	Hn	3.00	0.63	F
24	Sex Determination	2.36	1.01	Hn	3.33	1.21	F
25	Sex Linkage	2.24	0.95	Hn	3.17	0.75	F
26	Gene Mapping	2.17	0.95	Hn	2.67	0.82	F
27	Cytological Evidence of Crossing Over	2.05	0.95	Hn	2.67	0.82	F
28	Sex-linked Inheritance	2.21	0.97	Hn	3.17	0.98	F
29	Sex-limited Inheritance	2.22	0.96	Hn	3.17	0.98	F
30	Sex-influence Inheritance	2.27	1.03	Hn	3.17	0.98	F
31	Structural Variation in Chromosome Number	2.10	1.00	Hn	3.00	0.89	F
32	Chromosome Aberration	2.10	0.98	Hn	3.17	1.17	F
33	Gene Mutation	2.16	1.01	Hn	3.00	0.89	F
34	Mutagenic Agents	2.09	0.95	Hn	3.17	1.17	F
35	Significance of Mutations	2.28	0.98	Hn	3.00	1.27	F
36	Oncogenes	2.04	0.99	Hn	3.17	0.75	F
37	Allelic and Genotypic Frequencies	2.05	0.91	Hn	2.83	0.75	F
38	Hardy-Weinberg Equilibrium	2.05	0.91	Hn	2.83	0.98	F
39	Changes in Gene Expression	2.12	0.93	Hn	2.83	0.75	F
40	Mutations	2.24	0.93	Hn	2.83	0.98	F
41	Natural Selection	2.34	0.96	Hn	3.00	0.89	F
42	Genetic Drift	2.17	0.99	Hn	3.00	0.89	F
43	Genetic Flow and Migration	2.16	0.91	Hn	2.83	0.89	F
44	Preservation of Genetic Material	2.18	0.92	Hn	2.67	0.82	F
45	Genetic Modification through Hybridization	2.15	0.90	Hn	2.67	1.21	F
46	Production of Transgenic Organisms	2.06	0.93	Hn	2.5	1.05	F
47	Stem Cells	2.35	0.96	Hn	2.67	1.21	F
48	Gene Therapy	2.20	0.87	Hn	2.83	1.47	F
	Weighted Mean	*2.33*	*1.00*	Hn	3.21	0.99	F

Legend: 1.00 – 1.80 (Very Highly Online, VHn); 1.81 – 2.40 (Highly Online, Hn); 2.41 – 3.40 (Flexible, F); 3.41 – 4.20 (Highly Offline, Hf); 4.21 – 5.00 (Very Highly Offline, VHf)

Table 3. P-values on Year Level (YL), STEM Stand (SSt), and Gender (Ge)

No	Genetics Topics	p-values		
		YL	SSt	Ge
1	Definition and Importance of Genetics	0.351	0.515	0.190
2	History of Genetics	0.194	0.079	0.030
3	Principles of Inheritance	0.118	0.088	0.341
4	Basic Concept of Genetics	0.794	0.003	0.414
5	Significance of Genetics in Society	0.099	0.005	0.563
6	Characteristics of Useful Experimental Organisms	0.388	0.022	0.805
7	Basic Genetics Terms	0.254	0.150	0.070
8	Cell Structure	0.155	0.008	0.398
9	Cell Division	0.178	0.101	0.956
10	Life Cycle	0.270	0.106	0.738
11	Chromosome Type	0.110	0.272	0.946
12	Chromosome Morphology	0.435	0.321	0.522
13	Chemical Composition of the Chromosome	0.516	0.147	0.279
14	DNA Structure and Composition	0.610	0.201	0.356
15	RNA Structure and Composition	0.923	0.179	0.378
16	DNA Replication	0.905	0.421	0.252
17	Protein Synthesis	0.594	0.240	0.749
18	The Genetic Code	0.460	0.013	0.953
19	Monohybrid Inheritance	0.493	0.256	0.959
20	Dihybrid Inheritance	0.831	0.240	0.809
21	Multiple Alleles	0.911	0.132	0.696
22	Sex-linked traits	0.552	0.741	0.531
23	Environmental Influence on Gene Expression	0.556	0.196	0.706
24	Sex Determination	0.503	0.186	0.793
25	Sex Linkage	0.214	0.033	0.976
26	Gene Mapping	0.577	0.743	0.799
27	Cytological Evidence of Crossing Over	0.702	0.494	0.491
28	Sex-linked Inheritance	0.507	0.276	0.134
29	Sex-limited Inheritance	0.904	0.208	0.92
30	Sex-influence Inheritance	0.630	0.149	0.929
31	Structural Variation in Chromosome Number	0.309	0.382	0.406
32	Chromosome Aberration	0.913	0.652	0.034
33	Gene Mutation	0.241	0.261	0.837
34	Mutagenic Agents	0.614	0.346	0.892
35	Significance of Mutations	0.439	0.278	0.856
36	Oncogenes	0.443	0.686	0.194
37	Allelic and Genotypic Frequencies	0.547	0.702	0.438
38	Hardy-Weinberg Equilibrium	0.835	0.816	0.438
39	Changes in Gene Expression	0.730	0.656	0.683
40	Mutations	0.723	0.094	0.229
41	Natural Selection	0.491	0.383	0.557
42	Genetic Drift	0.484	0.645	0.631
43	Genetic Flow and Migration	0.697	0.124	0.386
44	Preservation of Genetic Material	0.893	0.750	0.452
45	Genetic Modification through Hybridization	0.480	0.781	0.470
46	Production of Transgenic Organisms	0.838	0.821	0.070
47	Stem Cells	0.194	0.442	0.798
48	Gene Therapy	0.211	0.292	0.521

Note: Tested at 0.05 alpha.

Year Level Influence on Flexible Genetics Instruction

Table 3 reports, among others, the p-values for sex, year level and strand type to determine the influence of these three elements to the instructional delivery preference on genetics topics as perceived by the respondents. Statistical analysis reveals that there is no significant difference between and among the respondents in their instructional delivery preference of genetics topics as either offline or online. This means that the first year, second year, and third year undergraduate students have statistically similar delivery preferences in a genetics course. Further, it should be noted in Table 1 that 4.9% of the respondents have already taken up the course in the previous semester and 39.0% of them were presently enrolled in a genetics course during the data-collection period for this study. Thus, since no significant difference exists between and among them, it could be said that similar results are conclusive between those who have finished the course already and those who are yet to take the course and the same could be said from those who were enrolled (that time) in genetics to those who are to enroll the subject in the succeeding semester or year. This further implies that the results could be generalizable to an even larger population of secondary science major students.

Strand Type Influence on Flexible Genetics Instruction

Table 3 generally reports no significant difference between the male and the female respondents in their instructional delivery preferences of the genetics topics as tested at 0.05 alpha level, except for six indicators (as shown in the table) which is 12.5% which reported a significant difference. It appears that strand type influences preferences in learning the topics. Basic Concept of Genetics, Significance of Genetics in Society, Characteristics of Useful Experimental Organisms, Cell Structure, The Genetic Code, and Sex Linkage. The researcher extracted the raw data from these six topics and reported comparative findings from both the respondents who graduated (Yes) from the STEM Strand and from those who did not (No), as shown in Table 3. Table 3 displays data that show Non-STEM Graduates who favor these topics to be delivered ‘highly online’. This may be because the scope of the undergraduate introductory genetics course is aligned with the subject content of major courses enrolled in STEM strands in senior high schools in the Philippines. STEM graduates will generally prefer to have these topics to be delivered in a ‘Flexible’ setting because these topics may have already been discussed in their senior high school.

Gender Influence on Flexible Genetics Instruction

Findings generally showed no significant difference between the male and the female respondents in their instructional delivery preferences of the genetics topics as tested at 0.05 alpha level, except for 2 indicators which is 4.16% which reported a significant difference. The topics on ‘History of Genetics’ and ‘Chromosome Aberration’ registered a p-value lower than the alpha value set (0.05) which is 0.030 and 0.034, respectively. The researcher extracted the raw data from these two topics and reported comparative findings from both the male and female respondents. Findings showed that female respondents favor both topics to be delivered 'highly online'. This is explained by the general belief that girls love reading more than do male students, and that these 2 topics require much reading, compared with all the other topics.

CONCLUSION

In terms of genetics instruction, undergraduate students believe that flexible instruction could be the new norm of learning as brought about by this COVID-19 Pandemic and accepted the idea that flexible instruction leads to greater chances of passing a subject because topics could either be delivered through a synchronous or an asynchronous modality. Though genetics as a course has been considered by the respondents to be potentially delivered as 'Highly Online', no significant difference has been found in their perceptions in terms of year level which implies that any instructional framework done based on the study findings are applicable and replicable in any other year level. While a few of the topics, particularly in the first few chapters of the course, were received or perceived differently by the respondents, the numbers of topics that showed significant differences both in terms of post-secondary track and gender will not amount to a necessary change in the instructional modality already in place for undergraduate genetics instruction in the Philippines. Most of the topics that showed significant differences reported that female respondents and non-STEM graduates do favor genetics topics to be delivered highly online which were not considered to be as much by male and STEM graduate respondents.

On the other hand, teacher-respondents believe that the genetics undergraduate curriculum could be delivered in a 'Flexible Manner' with most of the topics possible for a highly offline learning modality. This difference in perception of whether genetics as a course during the COVID-19 pandemic could be delivered offline, online, or in a flexible manner between the students and teachers does not necessarily mean that the perception of teachers should be followed, because after all, the receiver of learning are the learners and what they prefer is one key to promoting effective teaching. Thus, a learner-friendly curriculum.

The necessary modification to teaching and classroom instruction has brought necessary areas of research undertakings. Not conducting studies under these areas will lead to paralysis of quality instruction from the basic education to the graduate level. Curriculum assessment has been a common treatment imposed by educational institutions to measure how much has and has not been attained. Doing curriculum assessment is a healthy approach to increasing the quality of education at the time of a pandemic when institutions have made sudden shifts to instructional delivery. With this, it is recommended that periodic assessment of the genetics list be conducted after a semester or when at least a cohort of the student-respondents have all graduated to reflect the preference of the next cohort most appropriately. Further, an achievement test in genetics needs to be developed and administered to measure the achievement of the topics (and their instructional competencies) to test whether students' perceptions on learning genetics translate to the desired educational outcomes.

Implications for Curriculum, Instruction, and Assessment

In this context, 'implications' would refer to how the findings may be important for policy, practice, theory, and subsequent research. The following implications are drawn in terms of Curriculum, Instruction, and Assessment (CIA) Triad Framework:

Finding	Area	Implication
Diversity in Instructional Delivery Preferences	Curriculum	The study indicates that students have diverse preferences for the instructional delivery of genetics topics. This diversity suggests a need for a flexible curriculum that can cater to various learning preferences, balancing both online and offline components
Emphasis on First Chapter Topics	Curriculum	The first chapter topics are perceived as more flexible in terms of instructional delivery. This suggests that foundational and introductory topics may benefit from a more adaptable approach, allowing educators to choose the most effective mode of delivery based on the content
Preference for Online Instruction	Instruction	A significant proportion of students prefer highly online instructional modes for most genetics topics. This implies a need for instructors to incorporate effective online teaching strategies, resources, and platforms into their teaching methods
Incorporating Technology	Instruction	Given the high usage of mobile phones for online learning, instructors may consider incorporating mobile-friendly resources and interactive content to engage students effectively.
Consideration of Topic Complexity	Instruction	The study suggests that more complex topics in genetics are preferred to be delivered online. Instructors may consider the complexity of each topic when deciding on the mode of delivery, ensuring that the chosen method aligns with the content's level of difficulty.
Professional Development for Instructors	Instruction	Instructors may benefit from professional development opportunities to enhance their skills in delivering genetics content through diverse instructional modes. This can contribute to creating a more inclusive learning environment.
Alignment with Instructional Preferences	Assessment	Assessments may be designed in a way that aligns with students' instructional preferences. For topics that are preferred to be delivered online, assessments can include elements that assess understanding in an online format.
Balancing Online and Offline	Assessment	Assessment: Since students have diverse preferences for instructional delivery, assessments should also be balanced between online and offline formats. This allows students to

Finding	Area	Implication
		demonstrate their understanding in the mode they find most effective.
Consideration of Previous Knowledge	Instruction	The study suggests that STEM graduates may have different preferences, potentially due to prior exposure in high school. Curriculum developers may consider aligning introductory genetics courses with the content covered in STEM strands in high school.
Continuous Feedback and Adaptation	Assessment	Regular feedback from students regarding the effectiveness of instructional delivery methods is crucial. Instructors are encouraged to be open to feedback and adapt their methods accordingly to meet the evolving needs and preferences of students.

SUGGESTIONS

Immediate recommendations or suggestions relative to these implications include the (1) need to revisit genetics lesson offered among Non-STEM Track students in senior high school and develop a concept map to connect these topics to the corresponding topics in the STEM Track – this will provide a list of bridging topics to Non-STEM learners who may opt to enroll in the BS in Secondary Education Major in Science, or in any STEM-related degree programs where genetics is a foundation course; (2) develop an instructional material for the topics which were considered Highly Offline by the teacher-respondents and adjust the number of hours to be utilized in teaching those topics which are identified by student-respondents as complex (i.e. needing highly online delivery – meaning they can do it themselves); and, (3) initiate or at least provide initiatives in developing or cause to develop mobile apps, games, and other digital tools which the students can use to learn and/or re-learn genetics concepts particularly for those topics which were considered ‘flexible’, once develop, have it pilot-tested, then assess its technology acceptance model for target users. Of these suggestions, internal and external stakeholders are strongly encouraged to be involved, particularly those learned or are established in the field of curriculum development, instructional innovations, and futuristic student learning assessment for higher education. Finally, further studies may be conducted to other degree programs that include genetics as its foundation course.

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