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Validation of Gamified Instructional Materials in Genetics for Grade 12 STEM Students

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Abstract

Instructional material is an integral part of teaching and learning process. Validating instructional materials is imperative to ensure quality before widespread utilization. This study validated the developed Gamified Instructional Material (GIM) in genetics for grade 12 STEM students. It employed the descriptive-developmental research design involving 41 STEM students and 11 Biology education experts chosen through purposive sampling. Findings revealed that students and experts strongly agreed that the GIM satisfied the criteria for a sound and valid instructional material. Further, the significant change in the pretest and posttest scores of students indicated an improvement of their knowledge in genetics. It is recommended that the GIM be used as supplementary instructional material in teaching genetics.

Keywords: gamification; gamified instructional material; genetics; STEM; validation.

1. Introduction

Instructional materials may come in varied forms like textbooks, modules, manuals, or worksheets which help teachers cultivate students' knowledge [1]. These are imperative in teaching and learning processes. The Department of Education (DepEd) Order 39 Series of 2016 titled, "Adoption of the Basic Education Research Agenda," encourages teachers to conduct an evidence-based study on different teaching strategies and develop lesson plans and instructional materials [2].

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DepEd targets to produce materials which have undergone thorough research to ensure the developed materials' effectiveness and validity. In line with this goal, this study utilized gamification and determined the validity of the developed instructional material in Genetics for grade 12 Science, Technology, Engineering and Mathematics (STEM) strand. The determination of validity is significant prior to distribution of any instructional material to ascertain its readiness for utilization.

1.1. Gamification

Gamification is the use of game mechanics in a non-gaming context which, when utilized as an approach in teaching, engender good results in engaging students to learn [3,4]. This positively affects students' performance by decreasing cognitive load, improving learning achievements, and increasing student's motivation [5]. However, a suitable strategy in integrating and implementing gamification in education should be done in order to prevent its adverse effects such as increased rivalry and task difficulties [6,7]. To assess the suitability of strategy in the integration of gamification and instructional material, this study validated the developed Gamified Instructional Material (GIM) in genetics. Current trends in gamification make use of game elements such as badges, power cards, game mechanics, levels, unlocking contents, and leaderboards by developing and utilizing computers and program softwares played by students. Gamification in education was found to demonstrate positive effects on students' performance and motivation [5,8,9,10]. With the existing researches on gamification where the use of computer and software are rampant, this may not address the diversity of the learners in the Philippines because not all of students have access to computers and the internet. As a result, the GIM aimed to address the need to gamify instructions in areas where technology is limited to reach out for students with difficulties in computer accessibility. This is one of the innovative teaching materials patterned from the DepEd K-12 Curriculum Guide (CG) and the Teacher's Guide (TG) for senior high school to aid in teaching and learning processes.

1.2. GIM in genetics

The developed GIM in genetics is a tangible instructional material designed employing the use of modern technologies and game elements. It consists of two parts: Student's Portfolio and Seven Gamified Lesson Plans [11]. The first part is the student's portfolio where students keep their records, scores, and other players' significant data which make students' learning gamified, fun, motivating, and exciting. The second part is the seven gamified lesson plans which serve as basis and guide for teachers in the delivery of the lessons in genetics under General Biology 2.

1.3. Purposes of the Research

The study validated the GIM in genetics for grade 12 STEM students enrolled in General Biology 2, school year 2018-2019. It specifically aimed to: (1) evaluate the validity of the GIM based on experts in Biology education along student's portfolio and seven gamified lesson plans; (2) determine the students' acceptability of the material; and (3) assess the effectiveness of the GIM.

2. Methodology

2.1. Research Design

The study employed the descriptive-developmental research design in determining the validity of developed GIM in Genetics for grade 12 STEM. Particularly, the researchers utilized the Analysis, Design, Development, Implement, Evaluate (ADDIE) model. This paper concentrated on the discussion of implementation and evaluation phase.

2.2. Sampling procedure and Participants

The respondents of this study were the students and the experts chosen through purposive sampling. The students came from one intact class of grade 12 STEM comprising of 19 females and 22 males. They came from a government-owned secondary school in Sorsogon province who were officially enrolled in general biology 2 school year 2018-2019 under K-12 curriculum. Whereas, the experts were composed of 11 teachers in biology education with more than five years of experience from different schools within the Sorsogon province division. The students and experts evaluated the GIM and its actual implementation using the Student's Evaluation Checklist (SEC) and the Expert's Evaluation Checklist (EEC) adapted from the study in [12]. The researchers followed the regular schedule to avoid disruption of classes during implementation.

2.3. Instruments

In collecting relevant data, the researcher utilized the following instruments:

Expert's Evaluation Checklist. This was used by the experts to evaluate the validity of the GIM, it is 5-point Likert scale adapted from the study in [12] which was modified to suit the study's purpose comprising of two parts. First is the student's portfolio and second is the lesson plan. The researcher conducted a dry-run to 25 experts from four secondary schools in Sorsogon province to determine the reliability. Using Cronbach's alpha, the EEC gained an overall score of .982. *Pretest and posttest*. This study adopted the Genetics Literacy Assessment Instrument (GLAI), 31 multiple-choice items, used to evaluate the knowledge of students in genetics before and after the treatment. It has an alpha coefficient of .995 (N = 395) for pre-course and .997 (N = 330) for post-course signifying that it is a good instrument to assess genetics literacy [13]. It was administered to the participants as pretest to gather the baseline information on students' prior knowledge in genetics and as a posttest to evaluate the students' learning of the content after using the GIM. *Student's Evaluation Checklist*. This was used by students to evaluate the acceptability of GIM. This is a 5-point Likert scale adapted from the study in [12]. Like EEC, it was modified focusing only on the student's portfolio. The researcher conducted a dry-run to 58 student-respondents from two sections in senior high school STEM-11 (N = 29) and GAS-12 (N = 29) obtaining an overall alpha coefficient of 0.75.

2.4. Data Collection

Data collection activities are explained as follows:

2.4.1. Implementation phase

The researchers followed ethical procedures by first seeking permission from the principal to conduct a research study in the institution. Then, as soon as the permission was approved, the researchers administered the pretest to the class. Each student received a copy of the student's portfolio. The game master introduced and discussed the game mechanics to ensure orderly and seamless delivery of the lessons. The student's portfolio served as ticket in entering the game. The implementation was conducted on the finals of the second semester school year 2018-2019. The researchers used the student's portfolio to collect significant data from students as well as to track their performance. Inside the portfolio was the game mechanics which served as a reminder for every player. The next pages indicated their pseudonyms and profiles. The incorporation of pseudonym may prevent competition against other students, thereby promoting competition within themselves [11]. In the character's profile, students were asked to illustrate their own characters and give them qualities they wanted, hence stimulating creativity and imagination. On the next page, students displayed their badges obtained when they successfully performed and completed certain tasks. The succeeding pages reflected their earned points. These points were based on the type and number of badges obtained. The teacher counted the total accumulated points every week for ranking and buying power cards. The students bought power cards by picking one card randomly for a price of 500 life points. Each card had a different capacity. It was the prerogative of the player when to use it. The latter pages of portfolio were intended for journal log in which space was provided for writing experiences. The game master explained the rules prior to the start of the game. The teacher required the students to update their portfolios and keep their contents, along with their identities unknown to others. Only the portfolio's owner and the researchers were allowed to access the data. After each lesson, some of them randomly underwent one-on-one interview with the teacher to discuss their portfolio's contents and their experiences of the lesson.

Figure 1: Students during the lesson proper.

The gamified lesson plans revolved around the topics in genetics stipulated in the K-12 curriculum. From it, seven lessons were developed, to wit: (1) Pedigree Analysis; (2) Sex Linkage and Recombination; (3) Modification to Mendel's Classic Ratios; (4) Molecular Structure of DNA, RNA, and Proteins; (5) DNA Replication and Protein Synthesis; (6) Genetic Engineering; and (7) Recombinant DNA. These lessons dealt on

the following topics i.e. Mendel's law of inheritance, Sex Linkage, Central Dogma of Molecular Biology, and Recombinant DNA. Along with these topics, there were different activities with corresponding points. Students who succeeded in accomplishing the activities received rewards. They also got additional rewards for reaching certain levels from Novice (lowest level) to Sage (highest level). When all the lessons were completed, the student who accumulated the highest number of points was proclaimed the winner.

2.4.2. Evaluation phase

The experts validated the GIM using the EEC during implementation by observing the actual lesson delivery. They examined the student's portfolio based on two indicators: (1) format and language; and (2) content; and the lesson plans based on five indicators: (1) objectives; (2) content; (3) format and language; (4) presentation; and (5) usefulness. The researchers executed lessons 1 and 2 for 100 minutes each; lessons 3 to 7 took 150 minutes each. This made a total of 950-minute completion time. After all the lessons in the GIM have been carried out, the students took the posttest and evaluated the GIM using the SEC. They examined the student's portfolio based on two indicators: (1) format and (2) content. Finally, the researchers compared the result of pretest (administered before the use of GIM) and posttest (administered after the use of GIM) and analyzed the responses from EEC and SEC. They improved the GIM based on the responses and recommendations of both students and experts.

2.5. Data Analysis Framework

At the end of all lessons, the researchers performed analyses of the data from EEC and SEC using descriptive statistics. The interpretation of mean rating obtained from EEC and SEC were as follows: 4.5-5.0 Strongly Agree/Excellent; 3.5-4.49 Agree/Very Good; 2.5-3.49 Undecided/Good; 1.5-2.49 Disagree/Fair; and 1.0-1.49 Strongly Disagree/Poor. Whereas, in order to compare the pretest and the posttest results, Hake's g, Cohen's d and paired sample t-test set at 0.05 level of significance were used. Adjectival description was used in reporting to support qualitative data.

3. Results and Discussion

The discussion of analyzed data and results are presented as follows:

3.1. Evaluation of the GIM based on the experts

Experts in biology education evaluated the validity of the GIM, specifically the student's portfolio and the lesson plans. They used the EEC with a scale of 1 to 5, with 1 as the lowest and 5 as the highest. *Student's Portfolio*. This is the first part of EEC. Table 1 shows the mean rating given by 11 experts. The overall average rating is 4.67, signifying an excellent evaluation of its validity. Likewise, its different aspects obtained an excellent rating ranging from 4.55 (content) to 4.78 (format and language), signifying high validity of the material.

Table 1: Validity of Student's Portfolio.

Aspects	Items	Weighted Mean	Interpretation
I. Format and Language	1. The layout of the portfolio is arranged in a logical and sequential order.	4.82	SA
	2. The instructions are clear and well-emphasized.	4.82	SA
	3. The font size and font style are readable.	5.00	SA
	4. The symbols used are well-defined.	4.73	SA
	5. The tables/diagrams are well presented and easy to understand.	4.64	SA
	6. Key points and key concepts are well highlighted to focus attention while reading.	4.73	SA
	7. Titles and subtitles in the Portfolio are clearly defined.	4.73	SA
	8. Illustrations, pictures, and captions are properly laid out.	4.64	SA
	9. The student's portfolio is generally formatted in a convenient manner considering the paper size used.	4.82	SA
	10. The language used is easy to understand.	4.82	SA
	11. The language used is clear, concise, and motivating.	4.82	SA
	Average	**4.78**	**SA**
II. Content	1. Objectives of the game are easily understandable.	4.73	SA
	2. Game mechanics are easily understandable.	4.91	SA
	3. The game can motivate students to finish the activities on time.	4.27	A
	4. The ideas and concepts of the game are clearly understandable.	4.64	SA
	5. The illustrations/captions can help in following the game's instructions.	4.82	SA
	6. The game could help students understand fully the lessons.	4.36	A
	7. The styles of illustrations and written expressions are appreciable.	4.36	A
	8. Reading and accomplishing the portfolio is enjoyable.	4.45	A
	9. It is easier to study genetics using game elements.	4.36	A
	10. The lesson is enjoyable until the end.	4.55	SA
	Average	**4.55**	**SA**
	Overall Average	**4.67**	**SA**

Legend: SA - Strongly Agree; A - Agree

In detail, particularly in format and language, the item 1I.3 obtained the highest score of 5.0. This means that the font style and font size used are excellent for readers. Whereas, items 1I.5 and 1I.8 got the lowest score of 4.64. This may be due to the font style and font size used that affected the placement of the said components. For these components to fit and maximize the spaces of a letter-sized paper, their sizes were reduced. In the second aspect pertaining contents, item 1II.2 got the highest score of 4.91. This shows that experts find the game mechanics easy to understand. This may be associated to item 1I.3, that because of the font style's and the font size's readability, game mechanics could be understood easily. Whereas, item 1II.3 obtained the lowest score of 4.27. This was manifested during the implementation of activities where students could not finish them with the time allotted. According to the study in [14], creating a highly engaging and full blown instructional game is difficult, costly and time consuming. However, it is not only the creation of the game that is time-consuming, but also the implementation. This may be due to three factors: eagerness to win, activities' level of difficulty, and time allocated considering students' capacity. Gamified lesson plans. The second part of EEC refers to the

seven gamified lesson plans adapted from the TG. It was divided into five aspects, namely: objectives, contents, format and language, presentation, and usefulness presented in table 2.

Table 2: Validity of Gamified Lesson Plans.

Aspects	Items	Weighted Mean	Interpretation
I. Objectives	1. The objectives are clearly stated in behavioral form.	4.91	SA
	2. The objectives are well-planned, formulated, and organized.	4.82	SA
	3. The objectives stated are specific, measurable, and attainable.	4.64	SA
	4. The objectives are relevant to the topics of each lesson.	4.82	SA
	5. The objectives take into account the student's needs.	4.91	SA
	Average	**4.82**	**SA**
II. Content	1. The content of each lesson is directly relevant to the defined objectives.	4.55	SA
	2. The content of each lesson is simple and easy to understand.	4.36	A
	3. The topics of each lesson are fully discussed.	4.36	A
	4. The topics are supported by illustrative examples, and the practice tasks are suited to the level of the students.	4.82	SA
	5. Each topic is given equal emphasis in the lesson.	4.55	SA
	Average	**4.53**	**SA**
III. Format and Language	1. The format/layout is well-organized, which makes the lessons more interesting.	4.91	SA
	2. The language used is easy to understand.	4.91	SA
	3. The language used is clear, concise, and motivating.	4.55	SA
	4. The symbols used are well-defined.	4.73	SA
	5. The instructions in the Lesson Plan are concise and easy to follow.	4.82	SA
	Average	**4.78**	**SA**
IV. Presentation	1. The topics are presented in a logical and sequential order.	4.73	SA
	2. The lessons of the GIM are presented in a unique and original form.	4.73	SA
	3. The learning activities are presented clearly.	4.82	SA
	4. The presentation of each lesson is attractive and interesting to the students.	4.55	SA
	5. Adequate examples are given to each topic.	4.55	SA
	Average	**4.67**	**SA**
V. Usefulness	1. The GIM motivates the students to study Genetics.	4.64	SA
	2. The GIM helps to master the topics in time.	4.27	A
	3. The GIM allows the students to use their time more efficiently.	4.36	A
	4. The GIM develops the analytical thinking and reasoning skills of students.	4.45	A
	5. The instructional material serves as a supplementary material that can cater the needs of the students.	4.55	SA
	Average	**4.45**	**A**
	Overall Average	**4.65**	**SA**

Legend: SA - Strongly Agree; A - Agree

For the first aspect pertaining to objectives, the overall experts' evaluation was excellent (4.82). Items 2I.1 and 2I.5 both achieved the highest scores of 4.91. Objectives were presented in two parts: first, for the developed GIM, and the other, for specific lesson plans. The first part refers to the outcome expected by using game elements, whereas, the second part refers to the objectives adapted from the TG. These objectives were stated in behavioral form targeting student's needs and curriculum's competencies which may increase students'

performances [15]. For the students to be knowledgeable about the objectives, these were presented to students as part of every session/discussion. Item 2I.3 got the lowest score of 4.64. This could be attributed to the objective's attainability which may also be linked to time (1II.3). Every lesson plan was ideally given a span of two hours. However, it was implemented in an hour per day for two sessions indicating continuation the next day. This intermittent implementation means carrying out of routinary activities before every lesson consuming more time which led to unattainability of objectives. Consequently, the score of item 2I.3 was affected by this scenario. For lesson plan's second part referring to contents, experts gave the highest score of 4.82 to item 2II.4. Going back to the lesson plan's first aspect, one of the items that obtained the highest score was 2I.5 pertaining to the objectives' suitability to address students' needs. Item 2II.4 shows that activities in the GIM are suited for student's level in congruence to 2I.5. This means that the content's suitability for students was in consonance with the GIM's objectives. Whereas, items 2II.2 and 2II.3 garnered the lowest score of 4.36. As mentioned, gamification is time-consuming. The use of game elements makes the lesson more complex. As a result, it needs more time to cover all the topics. Overall, the content obtained a score of 4.53, signifying that the lesson plans have excellent contents. The third aspect is the format and language. Item 2III.1 and 2III.2 obtained the highest score of 4.91. The format/layout of the lesson plan used the six E's (Engage, Explore, Explain, Elaborate, Evaluate, Enrich). This approach is favorable for the experimental group implying that this could have affected the layout and made the lesson more interesting [16]. Moreover, the use of simple English language may have contributed to the high score given for item 2III.2. Unlike item 1I.11 which obtained the second to the highest in student's portfolio, the item 2III.3 got the lowest score of 4.55 in the lesson plan. This may be due to the GIM's limitations because some of the terminologies included in the GIM were not defined. Hence, it was stated in the preface that it is not the intention of the GIM to supply all information in genetics. Format and Language got a total score of 4.78 signifying that experts strongly agreed that the format and language used in lesson plans were excellent. The lesson plans' fourth aspect is the presentation. Experts gave the highest score of 4.82 to item 2IV.3. This may be associated to the aforementioned items that got the highest scores such as the organization and suitability of objectives and contents, and the understandability of language used. These factors may have contributed to the clarity of presentation. Moreover, before the game started, the researcher conducted an orientation about game mechanics. This may be one of the reasons why students have a clear understanding not only of the activities in each lesson plan, but the whole game as well. This result is parallel with the study in [15] where students who got a significantly higher performance were the ones who had prior knowledge on the lesson's objectives that made them cooperate, leading to better performance results. In the presentation aspect, items 2IV.4 and 2IV.5 both obtained a lowest score of 4.55. This may be relevant to the items 2II.2, 2II.3, and 2III.3 which also gained the lowest scores. Even though the language used was easy to understand, there were contents and technical terms which were not defined in the GIM. Consequently, the material's attractiveness and adequacy as well as students' interest was affected. Likewise, due to time constraints in presenting each lesson, scores given in the material's adequacy of examples was affected. Overall, the presentation got a score of 4.67, signifying that lessons were well-presented. The usefulness of lesson plans obtained an overall score of 4.45. Item 2V.1 obtained a score of 4.64 showing that experts strongly agreed that the GIM is useful in motivating students to study genetics. Based on the result, motivation of students may be affected by the following factors: warm colors and shapes, game elements, and behavioral objectives [5,15,17]. These characteristics of the lesson plan motivated the students. In contrast, the lowest score given for usefulness was 4.27 for item 2V.2. This

could be attributed to the aforementioned items regarding time where it was mentioned that gamification is time-consuming. Thus, giving more time to execute the gamified lessons is important. Overall, the part two of the GIM relating to the lesson plans attained an excellent rating of 4.65 from the experts. However, like in the student's portfolio part, the items 2V.2 and 2V.3 having the time element got the lowest scores, 4.27 and 4.36, respectively. This suggests that though gamification is an excellent and remarkable strategy, it requires more time not only for teachers to successfully execute the lesson, but also for students to master the topics.

3.2. Evaluation of the GIM based on the students

Like experts, students also evaluated the developed GIM in genetics. This is significant as they are the primary recipients of this study. Hence, the result of this study aimed towards student learning. They utilized the SEC for the material's acceptability evaluation. It has two components: format and content focusing on the game and student's portfolio. Table 3 shows the level of students' acceptability along GIM's format and content.

Table 3: Level of students' acceptability.

Aspects		Weighted Mean	Interpretation
I. Format	1. The layout of the portfolio is arranged in a logical and sequential order.	4.83	SA
	2. The game mechanics are understandable.	4.68	SA
	3. The instructions in the portfolio are well emphasized	4.54	SA
	4. The font size and font style are readable	4.90	SA
	5. the symbols are very well-defined	4.56	SA
	6. The tables/diagrams are well presented and easy to understand	4.76	SA
	7. Key points and key concepts are well highlighted to focus attention while reading	4.68	SA
	8. Titles and subtitles are clearly defined	4.71	SA
	9. Illustrations, pictures, and captions are properly laid out for easy reference	4.63	SA
	10. The student's portfolio is generally formatted in a convenient manner considering the paper size used.	4.71	SA
	Average	**4.70**	**SA**
II. Content	1. I easily understood the objectives of the portfolio.	4.56	SA
	2. I easily understood the instructions of the game using the portfolio.	4.56	SA
	3. The game using portfolio motivates me to finish the activities on time.	4.78	SA
	4. I understood clearly the ideas/concepts of the game using the portfolio.	4.54	SA
	5. The illustrations/captions guided me easily in following the instructions of the game.	4.68	SA
	6. The game helped me to understand fully the topic.	4.44	A
	7. I appreciated the styles of illustrations and written expressions.	4.79	SA
	8. I enjoyed answering the activities/problems	4.37	A
	9. I found it easier to study genetics using game elements.	4.51	SA
	10. I enjoyed the lessons until it was done	4.59	SA
	Average	**4.58**	**SA**
	Overall average	**4.64**	**SA**

Legend: SA - Strongly Agree; A - Agree

As shown in table 3, in the format aspect, items 3I.4 and 3I.1 obtained the highest scores of 4.90 and 4.83, respectively. Like the expert's rating of student's portfolio, item 2I.3, which also refers to the readability of font style and font size got the highest score, signifying that experts and students both strongly agreed that the font style and font size used in the GIM are valid and acceptable. On the other hand, item 3I.3 obtained the lowest score of 4.54. This may be due to the confusions in journal logs. During the implementation phase where students were filling out their journal logs, a lot of questions were asked about the meaning of its components. These include interest/enjoyment, perceived competence, effort/importance, pressure/tension, perceived choice, value/usefulness, and relatedness. These definitions resulted to confusion among students. Thus, the journal log was revised and the definitions of each component were included on the final revision. Through this, the confusion of future players may be prevented. Overall, the format garnered an average score of 4.70, implying that it is highly acceptable. Next to format is content. Table 3 shows that item 3II.7 obtained the highest score of 4.79, implying that the style of illustration and written expressions were highly acceptable. As mentioned, it used warm colors and shapes affecting students' motivation [17]. Further, the developed material used simple English language along with font style and size which may be acceptable at students' level. Whereas, item 3II.8 obtained the lowest scores of 4.37. This pertains to the enjoyability as perceived by students in answering the activities. This may be attributed to the result obtained from SEC's first aspect, item 3II.3, that because of the undefined components, students may be having a hard time accomplishing their journals even if they enjoyed classroom activities. Student 7 and 16 commended the format, content, game and portfolio. However, though these elements are made well, their understanding of the topics is affected because of the noise created during activities. This result is parallel to the study in [18] that noise inside the classroom may adversely affect student's understanding. Overall, the use of game and portfolio was rated by students as excellent. Students commended the use of game elements in teaching. Moreover, they appreciated the teacher's efforts on presenting the lessons in a new way, making learning more fun and exciting.

3.3. Level of performance of grade 12 STEM students in the pretest and posttest

One of the major goals of GIM is to help students in learning genetics; thus, increasing their level of performance. Table 4 shows the result of pretest and posttest through mean gain and performance level and the adjectival description using Mastery Level Descriptive Equivalent (MLDE).

Table 4 shows that the overall mean for pretest is 10.7 with a corresponding performance level of 34.52%, indicating low mastery level of the topics. Whereas, the overall posttest registered a value of 13.75 with a corresponding performance level of 44.35%, signifying average mastery level of the topic. This shows that the mastery level of students had changed from low mastery level to average mastery level.

Looking at the Mean Normalized Gain (MNG), topics under the Nature of the Genetic Material obtained the highest score of .29, signifying that students gained knowledge on the basic concepts in genetics.

The TG provided by the DepEd encompasses contents and competencies for students to develop basic knowledge in genetics. This basic knowledge mostly pertains to the nature of the genetic material.

Table 4: Level of performance of grade 12 students in the pretest and posttest.

Topics	Total Items	Pretest			Posttest			*MNG*
		Mean Score	**PL (%)**	**Description**	**Mean Score**	**PL (%)**	**Description**	
I. Nature of the Genetic Material	8	3.29	41.16	AM	4.63	57.93	AM	.29
II. Transmission	4	1.46	36.59	AM	1.76	43.90	AM	.12
III. Gene Expression	6	1.17	19.51	LM	1.49	24.83	LM	.07
IV. Gene Regulation	4	1.71	42.68	AM	1.90	47.56	AM	.09
V. Evolution	3	0.41	13.82	VLM	0.85	28.46	LM	.17
VI. Genetics and Society	6	2.66	44.31	AM	3.12	52.03	AM	.14
Overall	**31**	**10.7**	**34.52**	**LM**	**13.75**	**44.35**	**AM**	**.15**

Thus, more of the topics under the Nature of Genetic Material were presented in the first parts of lesson plans which may not be affected much by the limitations of time gaining the highest result. Topics on Gene Expression obtained the lowest mean gain of .07. This means that the scores of posttests had gained very low compared to pretests. Items on IIIc pertaining genetic disorders got the lowest mean difference among the questions in gene expression affecting the overall mean to get lower. Time may also be accounted to the low gain in the test scores because questions on gene expressions were related to diseases. The contents and competencies provided by the TG mentioned the diseases associated to gene expression but due to time constraints, it was not elaborated. Overall, the MNG obtained a mean of .15, implying low gain. Although it was low, the MLDE result shows that students, after the intervention, moved a step higher from low mastery level to average mastery level, indicating progress in mastery level. The overall MLDE result of pretest and posttest advanced with the improvement of scores. However, aside from the gain, it is necessary to identify the difference between the test scores. By doing this, the improvement in scores may determine if the intervention is effective. Therefore, this study used paired sample t-Test (one-tailed) to identify the existence of significant difference between scores. Table 5 shows the result of the paired sample t-Test.

Table 5: Difference between the pretest and posttest.

Variables	**μ**	***t*** (one-tailed)	***df***	***P***	***d***
Pretest	10.68	-4.03	40	<0.001*	0.63
Posttest	13.76				

**significant @ $p < .05$*

As shown in table 5, one-tailed paired sample *t*-test result revealed a significant difference between pretest (μ = 10.68, s = 3.09) and posttest (μ = 13.76, s = 3.56) of grade 12 STEM students before and after the utilization of GIM (t_{40} = 4.027, p = <0.001, α = 0.05). This directs the study to reject the null hypothesis implying that the scores of grade-12 STEM students in the posttest is significantly higher than the pretest. This means that the intervention made is effective in increasing the level of performance. This result is parallel to the study in [5,10,19] where gamification utilized in teaching yielded positive effects on students' performance. To support the t-test result and measure how much the significant difference was, the study computed the Cohen's d. Table 5 reveals that the significant difference between pretest and posttest was large (d = 0.63), showing that the effect

size of the intervention is substantial on student knowledge gained even the mean normalized gain reflects a low outcome. Thus, the utilization of GIM is effective in increasing the level of performance of grade 12 STEM students in genetics.

4. Conclusions and recommendations

To deliver better education, it is imperative that instructional material undergo validation to ensure quality. This study aimed to validate the developed GIM in genetics for grade 12 STEM enrolled in General Biology 2, SY 2018-2019. Although experts found out that the GIM and gamification have limitations like being time-consuming and noise-inducing, the GIM, as a tangible material and the gamification, as a strategy, were effective in motivating and engaging students to learn. The GIM in general is valid based on the evaluation of experts and students. The result of this study may encourage teachers to develop innovative teaching materials to facilitate learning. Additionally, they may use the good qualities of GIM and gamification in developing instructional materials. The researchers recommend the replication of this study and the use of GIM and gamification to profoundly explain their effects to students and examine different variables; likewise, to address the material and strategy's weaknesses and limitations.

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