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Genetic Escapade: Development of Digital RPG for Teaching Non-Mendelian Genetics

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ABSTRACT

The underperformance of the Filipino learners in both national and international assessments is a call to improve teaching materials and strategies. Among innovative approaches in teaching, role-playing game (RPG) is one of the approaches in game-based learning that is seen to have increased educational potential in transforming contents into more enjoyable activities while improving higher-order thinking skills. This study aims to develop a digital RPG to improve conceptual understanding in non-Mendelian genetics. This study employed a developmental research design and utilized the Successive Approximation Model of instructional design (SAM). A needs assessment was conducted to determine least learned topic in science 9, the target users' familiarity with RPG and openness to using RPG, and benefits and challenges in game-based classroom. The development process was done in three phases: preparation, iterative design, and iterative development. The developed RPG was evaluated by five in-service grade 9 science teachers and three in-service ICT teachers. The developed game passed all criteria for evaluation and is recommended by the evaluators for approval for use in public schools.

Key Words: Digital Learning, Game-based Learning, RPG in Education, Non-Mendelian Genetics, Supplementary Material.

1. INTRODUCTION

The PISA 2022 results revealed that the Philippines still lags behind the world by ranking 77th out of 81 participating countries (Magsambol, 2024). According to the result presented by OECD (2023), the Philippines scored less than the OECD average in reading, mathematics, and science, especially in science where no Filipino learners are top performers. Learner performance can be attributed to several factors; yet, one of the relevant factors is the need for pedagogical innovations to cope with technological advancements and to address the present needs of digital-native learners (Anastasiadis et al., 2018). This is emphasized by Malahito and Quimbo (2020) that teachers are in competition with technological advancements to gain the attention of the learners and in keeping them engaged in the classroom.

One of the technology integrations in the classroom is game-based learning (GBL). Game-based learning is defined as an innovative teaching method in which digital and nondigital games are used in teaching educational skills and concepts. Various researches have explored how games can improve knowledge and skills acquisition, which element of the game contributes to its instructional effectiveness, and what are the applications that can be used for teaching, learning, and for assessment (Plass et al., 2020). Among educational games, one that is seen to have increased educational potential in improving teaching-learning experience is role-playing games (RPG). The elements present in an RPG is the one of the best mediums to transform content into play activities while working on improving higher-

order thinking skills (da Costa, 2024). RPGs do not only exhibit potential in improving motivation and engagement but also in fostering 21st century skills (Prager, 2019).

Based on the readings in related literature and studies, RPGs are used in different fields with an attempt to foster relevant 21st century skills and to improve learning experiences through a more motivating and engaging experience. In relation to this, this study aimed to achieve the following objectives:

- 1. Conduct needs assessment on the perceived difficulty in teaching and learning biology concepts in grade 9
- 2. Develop a digital RPG as supplementary material for teaching non-Mendelian Genetics
- 3. Evaluate the developed digital RPG Genetic Escapade in terms of content quality, instructional quality, technical quality, and other findings.

2. METHODS

2.1 Research Design

This study employed the developmental research design following the Successive Approximation Model (SAM) instructional design with quantitative and qualitative support. The SAM was the guide for the development process of the game. Quantitative data were gathered from the needs assessment survey and the ratings from evaluators. Qualitative data were gathered from open-ended questions and the comments and suggestions from evaluators.

2.2 Research Participants

Purposive sampling was used for the selection of research participants. As part of the needs assessment, three grade 9 science teachers and one grade 9 class were the respondents of the study. They were asked to answer a needs assessment questionnaire to determine least learned topic in science 9, the target users' familiarity with RPG and openness to using RPG, and benefits and challenges in game-based classroom. For the evaluation of the game, five inservice grade 9 science teachers and three in-service ICT teachers were purposely selected as evaluators. The evaluators were given a copy of the game and an evaluation rating sheet. The evaluators rated the game in terms of content quality, instructional quality, technical quality, and presence of errors.

2.3 Data Gathering Procedure

The data gathering procedure was divided into three phases, following the elements of the SAM for Instructional Design. The first part of the data gathering procedure is the preparation phase. This phase includes all the preparation needed towards the development of the material. In this phase, needs assessment was conducted through literature review and was supported with a local needs assessment survey. From the data gathered, topics were selected, content was prepared, and the assessment tools for pretest and posttest were made. For the iterative design phase, this includes the making of the storyline and the creation of the first design, including sprites and background. The initial design had undergone numerous reviews and revisions. In the iterative development phase, the first version was coded and was subjected to face validation by the adviser and panel members. The first version was revised according to the comments and suggestions of the adviser and panel members. During the iterative development stage, the second version was evaluated by the in-service teacher evaluators in terms of content, instructional, and technical quality. From the comments and suggestions of the teacher evaluators as well as the comments from the learner participants, the material had undergone final revision. Once the material was perfected, the material was ready for dissemination.



Figure 1. The Successive Approximation Model by Allen Interactions (2021)

3. RESULTS AND DISCUSSIONS

3.1 Needs Assessment of Grade 9 Teachers and Learners

The needs assessment results were the supporting bases for the development of the digital RPG Genetic Escapade. The major purpose of the needs assessment was to identify least learned competency in grade 9 science, the teachers and the learners' familiarity and openness to game-based learning and use of RPG in the classroom, the perceived benefits of learners in using games in the classroom, and the perceived challenges of teachers in using games as part of the teaching and learning process. The following tables and figures present the summary of the results from the needs assessment.

Table 1 shows the result of the first part of the needs assessment. The teachers were asked to rate the competencies according to how easy their learners grasp the concepts while the learners were asked to rate the topics according to how difficult it is for them to learn. The competency "Explain the different patterns of non-Mendelian inheritance" gained the highest mean for both teachers and learners: very difficult for teachers and moderately difficult for learners. This result supports the findings from several studies on least learned competencies in biology. One of these is the study conducted by Santos et al. (2021) wherein they determine the least mastered competencies in grade 9 obtained the lowest mastery including the topics non-mendelian inheritance and photosynthesis and respiration. In a study by Eviota and Boyles (2022) on the development of strategic intervention material, it was based on least-learned competencies in biology of 9 of learners from Surigao City. From their identified least mastered topics, this includes respiratory and circulatory system, heredity, biodiversity and evolution, and ecosystem. Similarly, a study by Nabua and Cantere (2024) identified topics in biology that have lowest mastery in the schools in Misamis Oriental. Topics identified to be of low mastery include animal and plant parts and functions, heredity, biodiversity and evolution, and ecosystem, which is consistent with the other studies.

	Mean	
Competency	Teachers	Learners
Explain how the respiratory and circulatory systems work together to	2.33	2.10
transport nutrients, gases, and other molecules to and from the different		
parts of the body		
Infer how one's lifestyle can affect the functioning of respiratory and	2.66	2.55
circulatory systems		
Explain the different patterns of non-Mendelian inheritance	3.66	2.90
Relate species extinction to the failure of populations of organisms to		2.60
adapt to abrupt changes in the environment		
Differentiate basic features and importance of photosynthesis and	3.33	2.90
respiration		

Table 1. Perceived	difficulty on	grade 9	science first	quarter c	ompetencies
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Note: 1.00-1.75 (very easy); 1.76-2.50 (moderately easy); 2.51-3.25 (moderately difficult); 3.26-4.00 (very difficult)

Table 2 shows how familiar both teachers and learners are with RPGs. Two out of three teachers have a degree of familiarity with RPG while only 60% of the learners are familiar with RPG. However, despite the non-neglectable percentage of teachers and learners that are not really familiar with RPGs, they are open and willing to try using it in the classroom as part of the teaching-learning process. Moreover, both teachers and learners show a high percentage of perceived effectiveness of using digital games in the classroom, 100% and 75%, respectively.

	Yes/Very		Somewhat		Not Really	
Questions	Teachers	Learners	Teachers	Learners	Teachers	Learners
Are you familiar with role-playing games	33%	35%	33%	25%	33%	40%
(RPG)?						
Are you open to using RPGs as a tool in	100%	45%	0%	40%	0%	15%
the teaching-learning process?						
Do you think digital games can be	100%	75%	0%	15%	0%	10%
effective tools for learning?						

Table 2. Familiarity and Openness to the use of RPG in classroom

Figure 2 shows the learners' perception on the potential benefits of using digital games in the classroom. 80% of the learners perceive that using digital games in the classroom as part of their learning experience makes learning more enjoyable. Other potential benefits of using digital games in the classroom are also recognized by the learners including improving academic performance (40%), enhancing engagement and participation (20%), and increasing learning motivation (20%). These benefits of digital games have been recognized in several studies. A study by Chen and Wu (2020) in a study where they examined the effect of digital games in the classroom revealed an improvement in student learning performance and motivation. Digital games are also found to increase student motivation and engagement in the teaching learning process (Sholichah et at., 2022; Katual, Drevin, & Goede, 2023).



Figure 2. Learners' perception on the potential benefits of using digital games in the classroom

Table 3 presents the summary of teachers' responses in the question "What are the potential challenges in using games in your classroom?" Although the teachers recognized the potential benefits of using games in the classroom, the school in general is not ready to support game-based learning approaches. In a study of Campillo-Ferrer et al. (2020), they found that learners have a hard time following the instructions using digital games which can impede the completion of the lesson. The study of Alzahrani, Fahd and Alhalafawy, Waleed (2022) also revealed that the main challenge in gamification and game-based learning is the lack of internet connectivity.

Theme	Code	Quote
Limited	Competency-aligned	Teacher 2: "There are limited game-based learning resources that are
Resources	games	aligned to the curriculum's learning competencies."
		Teacher 1: "no access to games that are fit to the learning
		content."
	Game-based learning	Teacher 1, 2, 3: "Schools do not have internet connection for student
	support	use."
		Teacher 1, 2, 3: "Not all students don't have digital devices to use
		the games in the classroom."
Time Constraints	Time consuming	Teacher 3: "Using games in the classroom will take time as students
		still need to be oriented."
Lacking	Untrained teachers	Teacher 2: "Teachers lack necessary ICT skills to facilitate the use of
Qualifications		games in the classroom."
		Teacher 3: "No training is given to teachers on facilitating game-
		based learning approaches."

Table 3. Teachers' perception on the potential challenges of using digital games in the classroom

3.2 Development of the digital RPG Genetic Escapade

The development process was based on the elements of the SAM instructional design where design and development are iterative. The game was designed following the theoretical frameworks it was anchored on and the results from the literature review and needs assessment. The game was developed and underwent a series of evaluation and revisions before reaching the final version. Figure 3 below shows the development flow of the game.



Figure 3. Development Flow of the Game

In the preparation phase, this included information gathering such as needs assessment and literature review. This part covered the gathering of information as bases and rationale for the development (see section 3.1). As part of the design phase, the story outline was constructed. The sprite sheets and game levels were created based on the initial storyline. As the storyline was improved, new elements were added in the game levels. The initial design was reviewed and revised in an iterative manner. Figure 4 shows the initial design samples in the iterative design phase.



Figure 4. Sample Sprites and Level Design

After the creation of sprite sheets and designing levels, the game was coded. Figure 5 shows samples of player activities found in the game. In figure 5a, this note is coded so that it might appear bigger or zoomed in when clicked. In figure 5b, a task prompt will appear when clicking a certain item in the game. Figure 5c shows a drag and drop activity the players need to solve.

(a) game notes

(b) game task **Figure 5. Sample In-game Activities**



(c) drag and drop

After producing the first version (Alpha version) of the game, it was subjected to try-outs to find bugs, errors, broken codes, and overlapping functionalities. Some elements and designs were also omitted and/or improved when found to be not a fit in the overall design of the game. Errors were corrected and codes were debugged, producing a modified version, the Beta Version. The Beta Version was distributed to expert evaluators and was implemented to target users. Inputs from experts and user participants were considered for revision. When no further revisions needed to be made, the game reached the final version: the Gold version. The game was exported as .apk file for mobile compatibility and .exe file for windows compatibility.

3.3 Evaluation of the Digital RPG Genetic Escapade

The Beta version of the game was evaluated by five in-service grade 9 science teachers and three in-service ICT teachers. Table 4 shows the summary of the ratings of the evaluators. Comments and suggestions from the evaluators were also considered in the revision of the game (see table 5).

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Criterion	Mean Rating	Mean Score**	Remarks	
Content Quality*	4.00	40.00	Very Satisfactory/Passed	
Instructional Quality*	3.98	39.80	Very Satisfactory/Passed	
Technical Quality*	3.59	46.67	Very Satisfactory/Passed	
Other Findings***	4.00	16.00	Not Present/Passed	

Table 4. Experts ²	' ratings of	the game
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Note: *1.00-1.75 (not satisfactory); 1.76-2.50 (poor); 2.51-3.25 (satisfactory); 3.26-4.00 (very satisfactory) ** Resource must score at least 30 points for content and instructional quality, at least 39 points for technical quality, and 16 points for other findings to pass each criterion.

*** 1.00-1.75 (do not evaluate further); 1.76-2.50 (requires major development); 2.51-3.25 (minor and must be fixed); 3.26-4.00 (not present)

Table 4 presents the ratings of the experts on the developed game Genetic Escapade. The content quality received a mean rating of 4.00 and a mean score of 40.00 indicating that the content of the game is consistent with the topics found in the learning competencies of the Department of Education. The content is also found to be relevant, promotes critical thinking, and helps in the mastery of learning objectives. Instructional received a mean rating of 3.98 and a mean score of 39.80. This result indicates that the game is stimulating, enjoyable, and achieves its main purpose. The developed game is also appropriate for the target users. Moreover, technical quality gained a mean rating of 3.59 and a mean score of 46.67. This rating indicates that the audio, visual, and design in general contribute to the enhancement of understanding of the content. However, the game was found to have minor glitches in controls and minor issues on the overall appearance of the visuals such as minimal cluttering of the texts. Finally, the Other Findings refers to the presence of conceptual, factual, grammatical or typographical, and/or visual errors. The game received a mean rating of 4.00 and a mean score of 16.00 in this criterion. This means that there were no significant errors found in the game. Overall, the game passed all four criteria of the DepEd LRMDS Evaluation Rating Sheet and all evaluators recommended the approval for possible use of this game in public schools, provided that the necessary revisions were applied and made.

Aspect	Suggestions
Content	ST4: "show the learning objectives at the start of the game."
	ST1: "Despite it being a supplementary material, make sure learners can see the learning
	objectives in the game."
Instructional	ST1: "Provide a map to guide learners their progress within the game."
Quality	ST5: "Provide more detailed explanation/feedback after answering each task."
	ST3: "Make it more engaging by incorporating a point system."
Technical Quality	ICT1: "Make variations of music to avoid monotony."
	ICT3: "Add hover effects and on-click effects during tasks to emphasize selection; make sure
	the letters are not draggable."

 Table 5. Summary of expert evaluators' suggestions for improvement

The expert evaluators commented that the game is conducive for learning, fun and stimulating to play, and aesthetically pleasing. The experts also stated that the interface of the game is clean and consistent with the overall design and the game mechanics if easy to understand. Both science and ICT evaluators acknowledged the potential of the game in increasing motivation and enhancing learning experience. However, the evaluators acknowledged there is still room for improvement in the game and gave suggestions. The game was revised and improved according to the suggestions by the expert evaluators.

4. CONCLUSION AND RECOMMENDATION

The digital RPG Genetic Escapade was developed with the aim to improve conceptual understanding in non-Mendelian genetics which was recognized as one of the least learned topics in recent literature and in the needs assessment. It was developed in an iterative manner, ensuring quality output. The game was evaluated by a panel of evaluators and passed all criteria. Based on the results, the digital RPG Genetic Escapade can be a valuable supplementary material for teaching non-Mendelian genetics by offering a fun and engaging way of learning new concepts. Furthermore, it is recommended to assess the effectiveness of the game in improving academic performance.

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