

An Analysis of Filipino Primary School Learners' Game Experience and STEM Interest within Minecraft

Jonathan CASANO ^{a*}, Maria Mercedes T. RODRIGO ^a

^a*Ateneo de Manila University, Philippines*

^{*}*jcasano@ateneo.edu*

Abstract: What-If Hypothetical Implementations using Minecraft (WHIMC) is a set of Minecraft worlds that students can explore to learn more about astronomy, geosciences, and ecology. In this paper we present an attempt to analyze the game experience and STEM interest answers of students who played WHIMC as guided by instructions in custom teacher-created learning modules that incorporate its use. We describe the process of remodeling the game experience questionnaire of IJsselsteijn et al. (2013) and the STEM interest questionnaire of Lent et al. (2008) to fit the context of WHIMC. Open-ended questions were added to the GEQ to facilitate further interpretation of the GEQ answers. The GEQ was administered once (after playing WHIMC) and the SIQ was given twice (before and after playing WHIMC) both as out-of-game tests. There was a noticeable neutrality in the SIQ answers of the low-performers, particularly in the dimensions of Self-Efficacy, Choice Goals and Outcome Expectation. The neutrality in the Self-Efficacy dimension shifted towards a higher degree of agreement in the post test. High-performing students showed consistently higher levels of agreement to the SIQ items compared to low-performers. In terms of the GEQ answers, the high- and low-performing groups share the same pattern of scores for each experience dimension. Low-performing students had higher scores in the Challenge dimension due to feeling time pressure. Open-ended answers showed that game- and learning-related WHIMC features were most liked, module-related difficulties were the most disliked, and game-related features were most instrumental to learning. High-performers reported that module-related aspects made the learning more difficult than it should be and low-performers said the technical bugs were the primary hurdles that made learning difficult.

Keywords: WHIMC, STEM interest, Philippines, Game Experience, Minecraft

1. Introduction

The What-If Hypothetical Implementations using Minecraft (WHIMC) project is a set of Minecraft worlds that learners can explore as supplementary activities to learn more about science, mathematics, engineering, and technology in general and astronomy, geosciences, and ecology specifically. WHIMC makes use of Minecraft's natural physics and mechanics to simulate science-related concepts. Finally, WHIMC immerses learners in simulations of conditions on certain exoplanets and on alternate versions of Earth, logging both the ways in which learners traverse these worlds and the observations that learners make during their explorations.

When engaging learners in open-ended environments such as Minecraft, assessment of learning and the learning experience is always a challenge (Park, 2019; Short, 2012). How can we determine what effect playing Minecraft has on the acquisition of knowledge or skills? Do students enjoy the game experience? Are there some types of learners who benefit from the game format more than others? In this paper we present an analysis of the game experience and STEM interest answers of students who played WHIMC as guided by instructions in custom teacher-created learning modules that incorporate its use.

Our formal research questions are the following: **RQ1:** How can game experience and STEM interest be measured in open-ended learning environments such as Minecraft? **RQ2:** What effect does

WHIMC game play have on students' STEM interest scores? **RQ3:** What is the difference between the game experience scores of the high- and low-performing students?

2. Review of Related Literature

Measuring the effects of games, especially those that are open-ended and less structured games such as Minecraft, has been a topic of continuing research (Šajben, 2020). Educators who use Minecraft for their classes use a variety of assessment methods to ascertain the effect of the game on student learning and the learning experience (Ekaputra, 2013). Educators in Malaysia, for example, implemented a Minecraft module on fractions that allowed students to produce what they called fraction models, i.e. structures or objects that represent fractions (Tangkui and Keong, 2021). Using pre- and post-tests, they found that students who used the Minecraft-based module showed greater achievement than those who learned fractions using traditional teaching methods. They attributed the success of the module to greater interactivity and greater engagement. Researchers also made use of self-reports and teacher observations (Overby, 2015). In an Australian high school, students were guided through a problem-based learning module on designing and building an ideal house (Callaghan, 2016). At the end of the activity, students were asked to respond to a student feedback survey regarding the use of Minecraft in general and as an educational tool. These assessments concluded that students were engaged in an authentic activity that promoted collaboration and the development of problem-solving skills.

In this paper, we present the outcomes of a Minecraft-based learning activity. We focus specifically on the effect of Minecraft on STEM interest.

3. Data Collection

Four schools from the Philippines were invited to identify topics in their respective academic level's curriculum where the use of WHIMC could be integrated. Teachers were asked to design learning modules that come with out-of-game assessments. After going through a review process to check for curriculum alignment, feasibility and quality, these modules were then tested out on their students. Table 1 summarizes the demographic details of the respondents.

Table 1. *Summary of demographic details of respondent groups*

Respondent Group		Module Implementation Dates	Total Student Respondents	Year Level and Subject	Age Range
PH School 1	Class 1	9/6 – 9/17, 2021	16	Grade 6	10 – 12 y/o
PH School 2	Class 2	10/6, 2021	31	Grade 4 & 5	9 – 11 y/o
PH School 3	Class 3	11/8, 2021	49	Grade 11	13 – 16 y/o
PH School 4	Class 4 to Class 12	between 12/15, 2021 and 3/16, 2022	233	Grade 7 & 8	10 – 14 y/o

3.1 Data Collection Design, GEQ and SIQ

During module implementation, the students were first asked to answer the STEM Interest Questionnaire (SIQ). After answering the SIQ, students were allowed access to the WHIMC worlds and were asked to follow the instructions described in the learning modules prepared by the teachers. After going through the module. The students were asked to answer the SIQ again together with the Game Experience Questionnaire (GEQ). Lastly, the students were asked to answer the out-of-game assessment questions that come with the teacher-created learning modules.

The Game Experience Questionnaire (GEQ) used in this study is an abridged version of the instrument developed by IJsselsteijn et al. (2013) to measure the factors in a game that contribute to an *engaging gameful experience* described across 7 dimensions of the player experience namely, Immersion [I], Flow [F], Competence [C], Positive Affect [P], Negative Affect [N], Tension [T] and Challenge [CH].

Four (4) open-ended questions were appended to the GEQ. These questions were, *What was your favorite part of the module and why?*, *What was your least favorite part of the module and why?*, *What about WHIMC made the topic fun, interesting, or easy to learn?* and *What about WHIMC made the topic boring and/or difficult to learn?*

The STEM Interest Questionnaire (SIQ) used in this study is likewise an abridged version of an original Student Interest and Choice in STEM (SIC-STEM) questionnaire developed by Roller et al. (2018) which was based on the Social Cognitive Career Theory (SCCT) questionnaire of Lent, Brown and Hackett (2008) that the following dimensions: **Self-Efficacy (SE)**, **Outcome Expectation (OE)**, **Interests (I)**, **Choice Goals (CG)** and **Choice Actions (CA)**.

3.2 Performance Categories

Using the scores gathered from the out of game assessments, the respondents were grouped into high- and low- performers via the method described in the work of Conati and Kardan (2013). Following this method, the scores of the respondents were first verified as being normally distributed (**PH School 1:** $\bar{x} = 40.18$, $\tilde{x} = 42.5$, $\kappa = -0.68$, $S_{\kappa P} = 0.51$, **PH School 2:** $\bar{x} = 12.78$, $\tilde{x} = 10.02$, $\kappa = -0.35$, $S_{\kappa P} = -0.32$, **PH School 3:** $\bar{x} = 61.9$, $\tilde{x} = 65$, $\kappa = -1.18$, $S_{\kappa P} = -0.41$, **PH School 4:** $\bar{x} = 82.22$, $\tilde{x} = 80$, $\kappa = -1.05$, $S_{\kappa P} = -0.11$) and performance was defined using the standard deviation and means. High-performers (HP) are students who received a total assessment score (s) that is greater than or equal to one standard deviation above the mean ($HP = s \geq \bar{x} + 1\sigma$) and low-performers (LP) are conversely defined as ($LP = s \leq \bar{x} - 1\sigma$).

4. Analysis and Results

4.1 Analyzing the GEQ Answers

A total of 593 rows of GEQ answers were considered in the analysis. A coding process was conducted to categorize the answers to the open-ended questions. These categories that surfaced out of the coding process were Game, Learning Content, Module/Teacher, Technical A (game constraints) and Technical B (game bugs).

Three coders were invited to categorize a total of 2372 open-ended answers. Each coder was given access to a spreadsheet where only the class numbers and corresponding open-ended answers were presented and was instructed to code independently. 1347 answers (56.79%) were unanimously coded. 986 answers (41.57%), where 2 coders were in agreement followed the majority rule. The coders convened to reach a consensus for the remaining 39 answers (1.64%) that have been coded differently by each coder.

4.1.1 Insights from the Answers to the Player Experience Items

The answers to the GEQ were aggregated per performance category to create Figure 1.

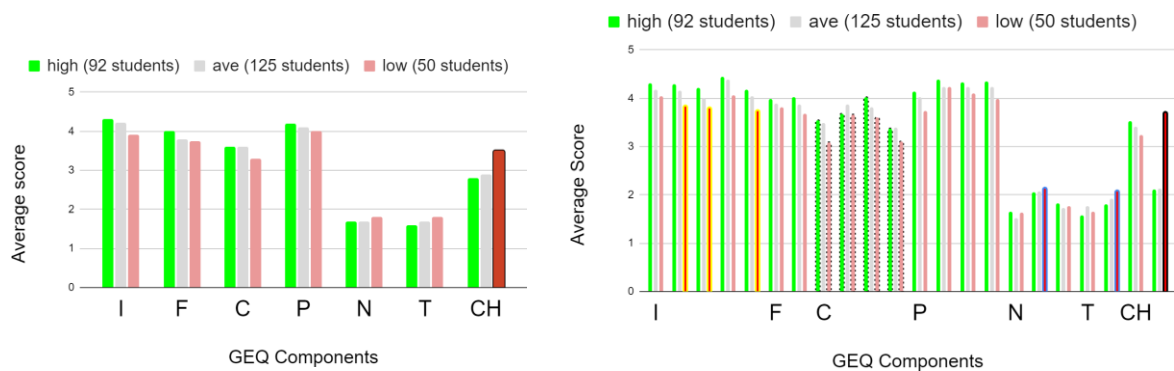


Figure 1. (left) GEQ component averages of the performance groups, (right) GEQ component player experience breakdown per performance group.

Low-performers found the game *moderately* aesthetically pleasing and impressive compared to the high-performers that found the experience *fairly* pleasing and impressive (red bars with solid yellow outline, 1 scale higher). The low-performers slightly outscored the high-performers in two items namely, *I found it tiresome* (N2) and *It felt frustrating* (T2) (red bars with blue outline), and greatly outscored the high-performers in the item *I felt time pressure* (CH2) (red bar with black outline). These observations were used to complement the insights drawn from the answers to the open-ended questions discussed in the next subsection.

4.1.2 Insights from Answers to the Open-ended Questions

Figure 3 shows a frequency distribution of the coded answers per performance category. We show how these findings relate to what was found in the analysis of the answers to the player experience dimensions above.

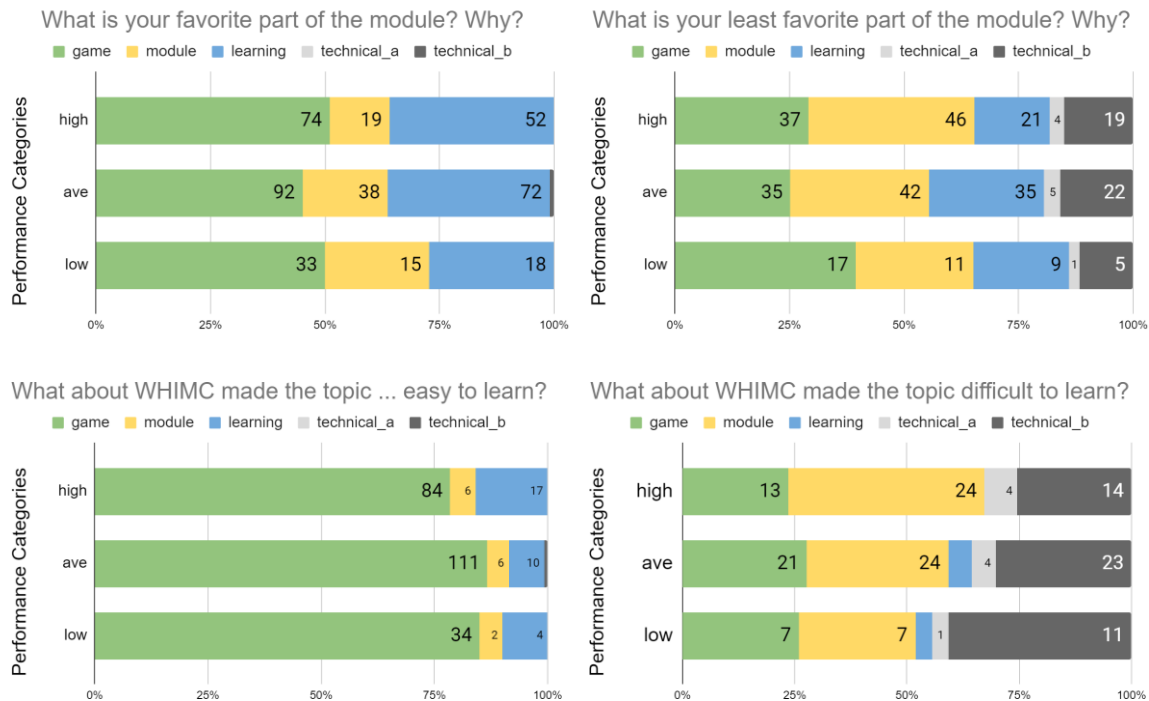


Figure 3. Answers to the open-ended questions appended to the GEQ.

In terms of most liked features, across the performance categories, students mentioned features related to the game as their most liked part of the experience. They were particularly pleased that the game allows for interaction with their classmates beyond the usual classroom discussion. Several students even noted that the session “*flew by so fast* (Flow F1) *because we were having fun* (Positive Affect P2) *exploring together* (Immersion I4)”. This shared exploration might have been a factor that supported the observed high scores in the Immersion, Flow and Positive Affect dimensions (Figure 1). The students also liked meeting and receiving information from the NPC’s about their work and the attributes of the altered Earths (44 out of 142 Learning answers or 30.0%) and how the simulations gave “*an interactive form to the information [they] normally would find in the textbooks*”.

In terms of least-liked features, majority of answers for this question fell into the categories of *Game* and *Module*. Students felt the repetitiveness of making observations was tedious and boring. In terms of the *Module*, students felt that the tasks contained in the modules were too strict such that they did not blend well with the affordances of an open-world game such as Minecraft which they assumed should be centered around free exploration.

Across all performance categories, game related features were dominantly seen as the factor that contributed to fun, interest and ease of learning and what made the game boring or difficult to learn were features relating to Modules (inherent complexity of the lessons) and technical bugs.

4.2 Analyzing the SIQ Answers

As mentioned in the Methodology, the respondents were instructed to answer the SIQ twice. Once before playing WHIMC and another round after playing WHIMC. Figure 4 presents the divergent stacked bar charts showing the aggregated responses of high- and low-performers for each question in the SIQ.

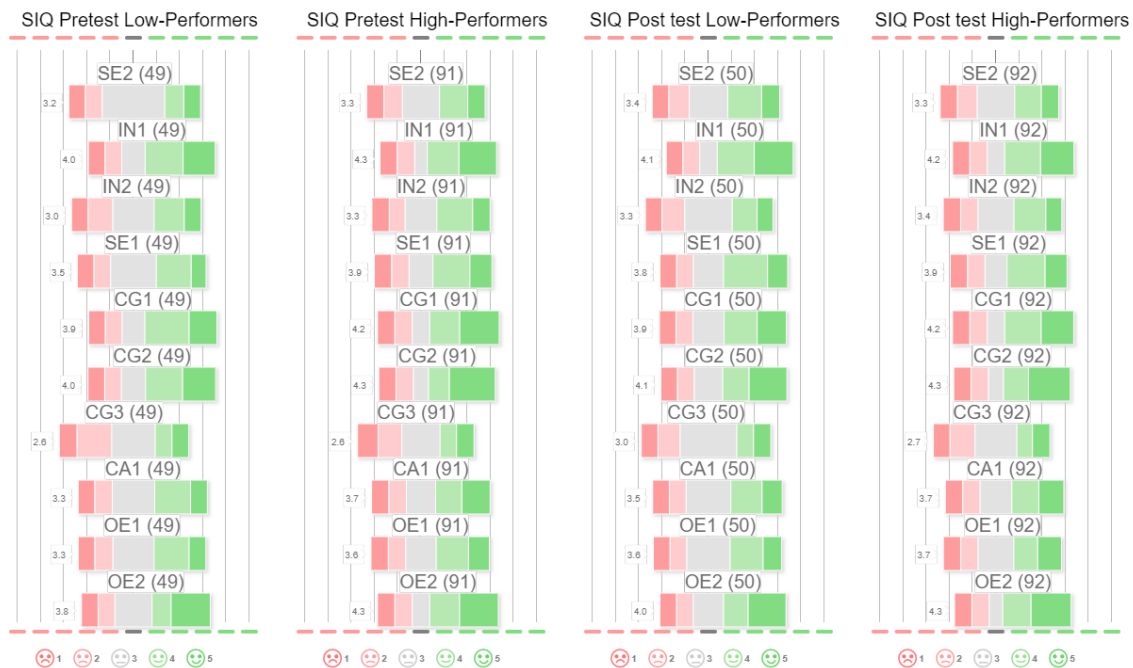


Figure 4. Divergent stacked bar charts representing the pretest and post test SIQ answers of high- and low-performing students.

4.2.1 Insights from the SIQ answers

At a glance, low-performers felt more neutral in most SIQ items than high-performers (gray bars). This is true for both the pretest and the post test. This neutrality is more pronounced in the questions pertaining to Self-Efficacy, Choice Goals and Outcome Expectation. This shows that the high-performing students generally believe in their ability to do STEM-related work and have more conviction in the significance of STEM concepts and skills in their future career.

The pretest and post test scores of the high-performing students stayed consistent. Most of the shift in the level of agreement was observed in the reported SIQ scores of the low-performing students. For instance, we note that when comparing the Pretest and Post-test graphs of the low-performing students, the neutralities for SE1 and SE2 have shifted towards a higher degree of agreement. This might mean that the WHIMC experience gave the low-performing students some degree of confidence in their ability to learn Science concepts while recognizing that it is also challenging.

Low-performers *enjoy solving Science and Math problems* (IN2) less than high-performers. High-performers also showed high agreement to CA1, OE1 and OE2 compared to the low-performers who were more neutral in their agreement to these items. These observations hold true for both the pretest and the post test.

5. Conclusion

In this paper we demonstrated how Game Experience and STEM interest may be measured in open-ended learning environments such as Minecraft by using WHIMC as a testing platform, and having students answer the GEQ and SIQ questionnaires after interacting with WHIMC [RQ1].

We note the following effect of using WHIMC in the STEM interest scores of the student respondents. There was a noticeable neutrality in the SIQ answers of the low-performers, particularly in the dimensions of Self-Efficacy, Choice Goals and Outcome Expectation. This shows that low-performers have a level of uncertainty with regards to their perceived ability to do STEM related tasks and well as to the significance of STEM in their future careers. In the post test however, the neutrality in the dimension of Self-Efficacy has decreased and shifted towards higher degree of agreement, showing that exposure to WHIMC might have equipped students with some level of esteem in doing STEM related tasks. High-performing students showed consistently higher levels of agreement to the SIQ items compared to low-performers [RQ2].

In terms of the GEQ answers, the high- and low-performing groups share the same pattern of scores for each experience dimension. The high-performers in the dimensions where a high score is desired such as Immersion, Flow, Competence and Positive Affect scored slightly higher than the low-performers, implying that the high-performing students had a slightly better overall game experience. Upon closer examination, low-performers felt time pressure with respect to the tasks contained in the modules. Perhaps giving these students more time to execute the instructions in the modules would be beneficial [RQ3].

Acknowledgements

The authors thank H Chad Lane and Jeff Ginger for their enthusiastic collaboration, Dominique Marie Antoinette Manahan, Maricel Esclamado, Mikael William Fuentes, and Ma. Rosario Madjos for their support, the Ateneo Laboratory for the Learning Sciences, the Ateneo de Manila University, our funding agency Department of Science and Technology (DOST) for the grant entitled, “Nurturing Interest in STEM among Filipino learners using Minecraft.”, and our Monitoring Agency The Philippine Council for Industry, Energy, and Emerging Technology Research and Development (DOST-PCIEERD).

References

- Callaghan, N. (2016). Investigating the role of Minecraft in *educational learning environments*. *Educational Media International*, 53(4), 244-260.
- Ekaputra, G., Lim, C., & Eng, K. I. (2013). Minecraft: A game as an education and scientific learning tool. *ISICO* 2013, 2013.
- IJsselstein, W. A., De Kort, Y. A., & Poels, K. (2013). The game experience questionnaire.
- Lent, R. W., & Brown, S. D. (2008). Social cognitive career theory and subjective well-being in the context of work. *Journal of Career Assessment*, 16(1), 6-21.
- Overby, A., & Jones, B. L. (2015). Virtual LEGOs: Incorporating Minecraft into the art education curriculum. *Art Education*, 68(1), 21-27.
- Park, J., Kim, S., Kim, A., & Mun, Y. Y. (2019). Learning to be better at the game: Performance vs. completion contingent reward for game-based learning. *Computers & Education*, 139, 1-15.
- Roller, S. A., Lampley, S. A., Dillihunt, M. L., Benfield, M. P., & Turner, M. W. (2018, June). Student attitudes toward STEM: A revised instrument of social cognitive career theory constructs (fundamental). In 2018 *ASEE Annual Conference & Exposition*.
- Šajben, J., Klimová, N., & Lovászová, G. (2020). Minecraft: Education Edition as a Game-Based Learning in Slovakia. In *the Proceedings of 12th annual International Conference on Education and New Learning Technologies* (pp. 1-8).
- Short, D. (2012). Teaching scientific concepts using a virtual world: Minecraft. *Teaching Science*, 58(3), 55-58.
- Tangkui, R. B., & Keong, T. C. (2021) Improving Achievements in Fractions: A Conceptual Framework for Digital Game-Based Learning Using Minecraft. *International Journal on E-Learning Practices (IJELP)*, 4, 76-91