

Gamified track-based remote instruction: Its use and impact on mathematics competence

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Abstract

The teaching of mathematics concerns difficulties, misconceptions, and challenges all wrapped into one, which pushed teachers for a personalized and direct instructional approach. However, with the loss of contact hours caused by the global pandemic, learners' mastery and competence on the subject matter are jeopardized. In this new normal, digitalized instruction and learning tools justify the continuity of education in any learning environment. Hence, a study examined the impact of a gamified track-based remote instruction on the level of competence of learners taking up Agri-Fishery and Home Economics strands in the Dolores National High School during the school year 2020-2021. The sequential-exploratory research design was undertaken, thereby collecting data such as selected participants' perceptions on the use of the proposed tool via focus group discussion during the piloting phase, assessment of learning gains during the quasi-experimental phase, and the determination of its impact on the participants' competence level using the identified four factors embedded on the extended Technology Acceptance Model (TAM) survey questionnaire. Findings showed that the use of a gamified track-based remote instruction enhanced the competency level of the two groups of participants. Also, out of the four factors, only self-efficacy was found to insignificantly predict participants' level of mathematics competence. Furthermore, the gamified track-based remote instruction can be implemented in other school and subject areas to supplement its effectiveness and maximize its use in the future.

Keywords: *gamified track-base remote instruction, mathematics competency, senior high school tracks*

Introduction

Mathematics applications in today's world are of great importance regarding science, technology, communication, and other fields (Dowling et al., 2001). The demands for competencies and mastery of core contents cannot be discounted in the rapidly changing world brought about by the global pandemic. Dahar (2011) opined that Mathematics Education has always faced challenges as a great number of learners complained of the difficulties in the subject and

that of students' laziness. As a matter of fact, Salveijo and his colleagues (2014) revealed that several learners fail in completing requirements, thereby getting low performances in both academics and logical reasoning skills, especially in disciplines like mathematics and sciences. The latest Program for International Student Assessment (PISA) results revealed that the Philippines scored 353 in mathematics, ranking below the participating Organization for Economic Co-operation and Development countries' average achievement (MoconCiriaco,

2019). In addition, in the 2003 Trends in International Mathematics and Science Study (TIMSS), Filipino students' mathematics performance belongs to the bottom 11%, better than 1999 results (Mullis et al., 2004). The poor performance in mathematics is of global concern attributed to many factors such as mastery of basic skills, time management, and attitude towards mathematics (Suan, 2014) and promoting students without achieving competencies needed for the level (Shahrill et al., 2015). The lack of mastery and learning among students on some learning competencies contributed to poor performance during National Achievement Tests and other related assessments (Linog, Lahoylahoy, & Alguno, 2013). The declining performance of Filipino students in mathematics triggered the need to overhaul the Philippines educational systems.

Continuity in education is a vital aspect that needs proper planning and implementation to meet the needs of a rapidly shifting and unpredictable global society. Telles-Langdon (2020) described the rapid change in the dynamics of the present educational system as an eyeopener among educators worldwide to defer themselves from the usual "sage on the stage approach" and give more focus on available technology-based infrastructure and digitalized approaches to instruction. True enough, the year 2020 forced almost all education sectors across the globe to equip and build teachers' capability in the use of technology to encounter acceptance, sustainability, and scalability challenges. The United Nations Educational, Scientific, and Cultural Organization (UNESCO, 2019) suggested that teachers implement a student-centered model of instruction and appreciate differentiated curriculum, instruction, and assessment paradigms. However, several authors mentioned the lack of resources, classroom deficiency, and a shortage of funds as contributing factors to the students' poor achievement, especially in the National Achievement Test (Ngema, 2016). According to Bruner (as cited by Orale, 2018), students are expected to learn when presented from simple to complex ideas based upon their previously learned knowledge. This particular approach to learning and the problems on the lack of instructional materials led the researchers to

develop an innovative learning material that can bridge the education spiral content paradigm gap, where students revisit topics on several occasions during a course using a teacher-provided instructional material.

The differentiated approach follows the progressive type of curriculum anchored on Dewey's Learner's Total Learning Experience theory. According to Zulueta and Maglaya (2002), this approach refers to choosing and defining the content using prevalent ideas. Cabansag (2014) opined that students exposed to this approach find topics or learning contents easy at first and gradually become hard, but there is mastery of the topics because they are discussed at their own pace. Moreover, Martin (2008) describes learners' spiraling journey to be more personal, thereby allowing them to develop their skills, knowledge, and understanding of challenging situations. With that, this project's proponents aimed to create a learning material that will enable the learners to bridge the gap between what they know and what they need to know through deepening the sub contents. The approach provides multiple opportunities for learners to gain mastery as they are exposed to the same content as the topic progresses. In an American school, it can be observed that they substantiate the proportion of time to review concepts, even exceeding repeating the topic over and over again just to master it (Gamoran, 2001).

It is observed in the proponents' classrooms that some students experience difficulty in performing operations on algebraic expressions since the topic requires learners' complete understanding of the principles regarding algebraic expressions and the rules in multiplying like and unlike terms. Moreover, the said competency has been consistently declared as least mastered for three years now. It is imperative to look for innovative approaches accompanied by learning tools to provide needed interventions for meaningful learning. Hence, the cyclical action research process was deemed necessary and appropriate in addressing the current learning gaps. The present research employed a sequential exploratory research design to magnify the impact of an intervention program in improving the participants' level of competence via a track-based remote learning

approach using PowerPoint features of a mobile learning application. The intervention was conducted among Grade 11 TVL Home Economics (HE) and Agri-Fishery (AF) classes in Dolores National High School during the first semester of 2020-2021.

Objectives of the study

An exploratory sequential study was conducted to determine the improvement made on the mathematics competence of Grade 11 students at Dolores National High School through the use of a gamified track-based cum remote learning approach in teaching least mastered competencies in General Mathematics during the first semester of the school year 2020-2021.

Specifically, the present study was guided by the following objectives.

1. Describe the perceptions of learners after the use of gamified and problem-based mathematics instruction.
2. Test if there is a significant difference between the learning gain scores of students exposed to gamified and problem-based mathematics instruction on least mastered competencies.
3. Determine which factors on the use of a gamified and problem-based mathematics instruction significantly predict(s) participants' level of competence.

Methodology **Research design**

The study utilized a sequential-exploratory research design, which according to Berman (2017), focuses on understanding behavior patterns and preferences qualitatively, which was augmented with the quantitative undertaking. Hence, this study was divided into various phases; the first phase is on the initial qualitative data collection and analysis, followed by the quantitative data collection analysis phase. In this phase, a quasi-experimental study was conducted to ascertain the significant difference of students' mathematics competence levels when exposed to gamified track-based instruction. Finally, a quantitative-evaluative approach was conducted to gauge the participants' perceptions and relate them using regression analysis to their mathematics competence level.

Participants of the study and sampling method

The participants of the study are the Grade 11 students of Dolores National High School who are enrolled in the Home Economics (HE) strand, under the Technical, Livelihood Track was specifically chosen as the participants of the study. The purposive sampling was used among students coming from two TVL sections to participate in this study. A total of 28 students in Grade 11 TVL HE and 30 students in Grade 11 TVL AF. Originally there were 30 participants from the TVL-HE but two of them back out and dropped from classes due to early pregnancies. The researcher selected them based on their final grade in their 10th Grade Simple Mathematics, with greater chances of being chosen among beginning (74% and below) and developing (75-79) level of academic performance and performance in the first self-learning module in General Mathematics for the School Year 2020-2021.

Data gathering procedure

Prior to the experimentation, the material was pilot tested among ten students from a non-participating class. The said activity underwent focus group discussion to identify factors that affect learners' understanding of the mathematical concepts using the proposed innovation. Likewise, themes and responses were added to the existing data on Technology Acceptance Model. In terms of reflexivity, the researchers conducted a limited face-to-face which is needed to consider how their professional experiences and prior assumptions might influence their interactions with the participants. The researchers ensured the validity of the data collection and organization by following audit trail procedures and presenting the interview transcript to the participants for finalization.

After finalizing the material, the quasi-experiment started from August 25 up to September 26, 2020. A 25-item researcher-made pretest instrument was administered to identify learners' level of competence regarding the least mastered competencies in the subject General Mathematics. This instrument underwent rapid validation among mathematics teachers in the said school and was pilot tested to a non-

participating class, resulting in an 82% alpha reliability value. Since this study aims to validate the effectiveness of the material, the pretest result served as a diagnostic representation of the two groups. Moreover, the said instrument was used for the posttest assessment. The gamified track-based instruction utilized PowerPoint-based instructional tool through the use of hyperlinks, animations, and contextualized activities modified in such a way that the learners will get to have a hands-on experience in solving a problem involving functions aided by QR code-based key cards.

As mentioned earlier, two classes in Grade 11 were utilized as participants of the study, both exposed to a gamified and problem-based mathematics instruction provided with a load card and USB flash drive, due to lack of face-to-face classes and health issues. The said intervention was purely driven by the concept of remote/distance learning, wherein teacher-researchers just standby and wait for a call from the student on problems and issues they are facing in the use of the learning materials. After experimentation, the respondent was made to answer a 20-item modified Technology Acceptance Model (TAM) survey questionnaire using google form. This modified questionnaire was validated by five (5) experts regarding its relevance, clarity, simplicity, and ambiguity using the Content Validity Rating Scale for the Survey Questionnaire adapted from Waltz and Bausell (1983).

Data analysis

A thematic analysis was performed to analyze the qualitative data collected in Phase 1 (Pilot phase) following the five stages of qualitative data analysis developed by Ajjawi and Higgs (2007). First, audio recordings were played and transcribed. Then, the researchers coded the data leading to the generation of ideas and linking of themes. All these were refined later on by the researcher and some qualitative experts in the school's division of Eastern Samar.

In measuring the participants' level of competence, the researchers used the Performances Indicators Rubrics adapted from the Department of Education Order No. 8 series 2015 as measurements on the learning competencies Since this study followed a quasi-

experimental design, the comparison of the two groups' learning gains was conducted using a t-test for independent samples. Finally, the researcher employed a multiple hierarchical linear regression to determine which factors significantly predict participants' level of competence at 0.05 alpha value.

Ethical considerations

For ethical consideration, the confidentiality of the research outputs was placed in anonymity, and that the participants were informed on the purpose of the data gathering. The giving of rewards was employed to avoid instances where students will withdraw from the conduct of the research and that no force was made to compel them to participate.

Results and discussion

On learners' perceptions on the use of gamified track-based remote instruction

The transcripts from the focus group discussion among ten participants were scrutinized to derive an objectified listing of their experiences during the pre-utilization phase of the PowerPoint-based tool. Furthermore, to be familiarized with the gathered data, significant statements were labeled thru transcript numbers and line numbers for proximate identification. The qualitative findings revealed five distinct and interesting themes, namely; "Ease of use", "Technological quality", "Enjoyment", "Academic relief", and "Improved attention span".

Ease of use

The usefulness of learning material is crucial in attaining quality education. Juhary (2014) opines that the use of learning material, in her study via a Learning Management System (LMS), can be seen through constant and consistent use to enable a teacher to discuss a difficult lesson with ease. Moreover, Bates (2018) suggests the inclusion of graphics and screen design to augment ease on the use of any learning tools. Hence, participants' perceptions of the user-friendliness of the material should be considered in the development of any learning and teaching materials.

Participants in this study described the gamified and track-based instruction via PowerPoint-based tool as user friendly and easy to manipulate.

"If I am to describe the tool, it's easy to use, very handy, and enjoyable" - Ana, H.E.

"Though I have poor understanding in mathematics, the tool made it so easy for me to understand the concepts all by myself" - Kelly, A.F.

"The tool is accessible wherever I go" - Lovely, A.F.

"Simply, I can easily operate and learn the contents of the tool" - Moira, H.E.

Technological quality

When asked what aspect or component of the entire material is interesting to them, the majority responded with the learning material's technological aspect. Garfield (2020) strongly emphasized the inclusion of correct tools to ignite, enhance, and harness learners' innate skills. Di Trollo (2019) discussed the role of techno-creativity in allowing learners to leave their comfort zone, enabling them to move beyond the barriers of the 21st century. Thus, the inclusion of a hybridized instruction to the traditional ones can improve the whole teaching and learning system of the Department of Education.

It is evident from the statements below that the PowerPoint-based tool's technological component enhances the learners' participation.

"Since I am fond of playing online and offline games, the use of learning tool embedded in PowerPoint enables me to understand the concepts, interactively." Ares, A.F.

"The technological design and creativity with regards to motions and colors arouse my interest on the topic" - Lovely, A.F.

"From start until the end, it was full of interaction, at least I learn through an AI-aid" - Moira, H.E.

"I find it hard at first, but with aid of recorded sounds and linked activities it becomes easy for me to follow" - Mea, H.E.

Enjoyment

The use of activities indeed makes the whole educational process fun, engaging, and

participative. In an experimental study conducted by Hernik and Jaworska (2018) on the impact of four primary emotions, enjoyment was found to build a state of willingness to do difficult things, improve memory, and develop new solutions and knowledge. Al-Shara (2015) found that the implementation of learning resources is the most crucial factor affecting learners' enjoyment. Indeed, a teacher must offer an engaging learning opportunity to attract and increase learning.

The majority of the participants agreed on enjoyment as the lead emotion they felt during the instructional phase.

"There was a bit of worrying, but as time goes by I enjoyed a lot of the activities given" - Moira, H.E.

"I love math ever since, and the use of the teacher provided tool made me enjoy it a lot" - Ken, A.F.

"I enjoy learning things through teachers discussion, but the tool given enable me to enjoy the lessons with my own pace" - Max, A.F.

"I enjoyed every bit of activities, especially those that I encounter in my major subjects" - Louie, H.E.

Academic relief

Driven by the new normal scheme in providing continuity to education, the participants were asked about the impact of the PowerPoint based gamified and track-based instruction on their learning. Whereby, most of them considered the said innovative tool as that which provides academic relief. Garcia and Weiss (2020) opined that learning occurs where there are enough supports, especially for distance or remote instruction, and that works via intentional, personalized, and the availability of sufficient resources. This theme highlights empathy, resilience, self-control, which, according to Tough (2012) are long neglected in academic contexts and in developing academic curriculums. It is fit in the time of the CoVid-19 to ensure that all learners will be able to continue their educational journey at home through the use of innovative and self-paced instructional tools. In this current study, some participants revealed that teacher-given learning tools enable them to track their learning progress, believe in their self-worth, and achieve a higher level of commitment to learning.

"When teacher GF instructed me to use the tool, I was hesitant, but the whole thing allows me to understand the concepts better even without the aid of teachers, schoolmates, and teaching tools" – Ken, A.F.

"I was surprised with the outcomes, due to the non-interaction (physical) I forced myself to believe in my capacity to learn new concepts – but with the use of the learning tool, everything went well, and I can view my scores instantly – so it was even better than in the classroom set-up" Louie, H.E.

"I felt that I was never alone in this journey" – Anna, H.E.

"I was never expecting to learn much in this pandemic, but everything went fine due to the many interactive tasks placed on the learning tool" – Moira, H.E.

Improved attention span

Another major impact based on the thematic analysis was on the improvement of participants' attention span. Learning mathematical concepts requires patience and commitment to the derivation of knowledge. When asked how they managed their learning, some of them responded with openness and sustainability of ones' interest. This is in line with Jain's (2010) theory, which explains the role of an instructional tool in answering the multifaceted needs of every learner. Several participants mentioned that their attention span was improved from the regular ones that they are employing. This can be attributed to the technological and cellular-phone alike features of the entire innovations. King (2020) revealed that 95% of users are more engaged in e-learning tools due to creative visual contents and adaptable time format.

"Honestly, I rather play ML than answering activities in the modules, but the technological features of the learning material enables me to finish most of the activities ahead of the schedule" – Ken, A.F.

"I easily get distracted in finishing all my modules, but whenever my math teacher give me my module; it seems I am magnetized to do all the activities due to its interactive features" – Kyla, H.E.

Considering all the responses and the results of pilot testing of pre/post-test materials, the researcher adapts Weng et al. (2018) and Alharbi and Drew's (2014) Technology Acceptance

Model (TAM) instrument with the inclusion of sub-themes derived from the qualitative portion of this study. Furthermore, the instrument has undergone expert-based content validity, and finally, exploratory factor analysis (overall alpha value of .8921). Hence a 20-item modified TAM-based instrument was utilized focusing on; (1) perceived ease of use, (2) technological quality, (3) usefulness, and (4) self-efficacy.

Test of significant difference between the learning gain scores of students exposed to a gamified track-based remote instruction

Table 1. Test of significant difference between the learning gain scores of students exposed to a gamified and track-based mathematics instruction

Group	Learning Gain	SD	P-value	Decision	Interpretation
TVL – AF	64.94%	16.59%	0.1907	Retain H_0	Not Significant
TVL – HE	56.25%	31.45%			

a = .05 SD, Standard Deviation

Table 1 summarizes the results of the inferential statistics employed between the two groups of participants in terms of learning gain score equivalent and the t-test result. The participants from the TVL AF class acquired a higher learning gain result than TVL HE classes, by around 8.69%. These results confirm that both groups of participants exposed to gamified and track-based instruction, performed and achieved the necessary learning competence. Furthermore, the t-test analysis revealed a computed p-value higher than the expected level of significance set at .05, which signifies a not significant difference in learning gains between the two groups of students.

Similarly, Simamora, Saragih, and Hasratuddin (2019) found no significant difference in learners' mathematical problem-solving ability between the experimental and control groups. These findings unveiled that employing a similar approach through the use of a PowerPoint-based-gamified and track-based

instruction through differences in content as it is track-centered enhances both the mathematical competence of the learners from the two classes.

Predicting participants' level of competence through the use of a gamified track-based remote instruction in mathematics

Table 2 shows the result of the multiple hierarchical analysis employed on the TAM indicators: perceived ease of use, technological quality, usefulness, and self-efficacy. A very good and significant prediction was derived at 66.8%. Moreover, three out of the four TAM indicators were found to significantly predict the mathematical competence of the participants to wit are perceived ease of use ($\beta = 6.879$, $p = 0.000$), technological quality ($\beta = 1.756$, $p = 0.022$), and usefulness ($\beta = 1.372$, $p = 0.040$). Interestingly, the result shows that an increase of perceived ease of use also increases the score by around 6.870, while a lower increase can be seen in terms of usefulness. On the other hand, self-efficacy was found to negatively affect the learners' mathematical competence, though it is not statistically significant.

Table 2. Multiple hierarchical regression analysis on TAM indicators as predictors of learners' mathematical competence

Predictive Variables	β	P-value	Decision	Interpretation
Perceived Ease of use	6.870	.000	Retain H_0	Significant
Technological quality	1.756	.022	Retain H_0	Significant
Usefulness	1.372	.040	Retain H_0	Significant
Self-efficacy	-1.945	.079	Retain H_0	Not significant

Criterion variable: Score; $F(4, 25) = 12.575$, $R^2 = .668$ (66.8%); $p = .000$, $\alpha = 0.05$

Similarly, Bellini et al. (2019)'s findings on mathematical competence align with the present study in regressing an instrument's capability to enhance talents and numeracy skills. Overall, the use of PowerPoint-based gamified

and track-based instruction impacts the participants' level of mathematical competence.

Conclusions and recommendations

The researchers conducted this study to examine the perceptions, compare mathematics competence levels, and regress students' mathematics competence using TAM indicators. In light of the findings of the study, the following conclusions are presented. First, the qualitative results of the pilot-testing phase revealed the thematic perceptions of the participants on the use of gamified track-based remote learning in terms of ease of use, technological quality, enjoyment, academic relief, and improved attention span. After exposing them to the said instruction, the results showed no significant difference between the learning gain scores of the two groups. The said result shows that the gamified track-based remote learning approach can be used by students in all of the TechVoc tracks. Finally, among the four factors, self-efficacy was not a significant predictor of participants' competence level through the use of gamified track-based remote learning approach. The result, in general, shows that the use of the said approach effectively improves the mathematics competence of the learners.

Based on the study's conclusions, it is recommended that gamified track-based remote instruction should be implemented in other schools to confirm its effectiveness and maximize its use in the future. Likewise, it is suggested to conduct similar studies on the use of a gamified track-based remote instruction for remediation in other subject areas to confirm the result of the study.

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Declaration of conflict of interest

The authors declare that there is no conflict of interest. Proper authorization from the co-authors, especially the schools' division of Eastern Samar was given.

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