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MATHEMATICAL MOBILE APPS VIA RURAL CASTING

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ABSTRACT

This paper discusses the distribution, through a digital datacasting framework, of mathematical resources for Grades 1 to 7 to two schools in a community in the Philippines. Among the mathematical resources made available, are mathematical applications (apps), which run on mobile technologies, that have been created to help in the mathematical learning of students in a remote setting. The distribution is facilitated by the RuralCasting set-top box, a developed custom set-top box capable of receiving digital TV broadcasts and providing local content access through its Wi-Fi network. This paper presents the performance of the set-top box in distributing the mobile mathematical apps, and a short discussion on the mathematical applications deployed.

KEYWORDS

Mobile Technology in Teaching Mathematics, Datacasting, Mathematical Apps

1. INTRODUCTION

In the Philippines, based on the National ICT Household Survey (Department of Information and Communications Technology, 2019) only about 17.7% of households have access to the internet. As such, the Philippine Department of Education's, blended learning approach during the time of the Covid-19 pandemic, focused largely on non-internet sources such as printed modules, radio and television. There was a need to explore alternative avenues for the delivery of information and resources for teaching and learning. The Department of Science and Technology- Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST-PCIEERD) and the Department of Science and Technology - Advanced Science Technology Institute (DOST-ASTI) led an initiative aiming to develop technologies that maximize the use of the UHF spectrum (e.g., the use of TV whitespaces for LTE mobile broadband services, use of digital TV datacasting framework) for the deployment of information.

This paper discusses the results of a project under this government initiative, where the datacasting capabilities of the ISDB-T Digital TV standard adopted by the Philippines has been maximized by sending different file formats furthering the cause of distance learning and contributing to the availability of educational resources in areas and communities where internet infrastructure is unreliable or non-existent. In particular, a custom *set-top box* was developed that was able to receive the usual TV programming, along with the attached data content, providing multiple users access to the content thru Wi-Fi, and return information back using alternative transmission methodologies.

One of the resources that were distributed through the set top box were mathematical applications (apps) that run on mobile technologies. Even before the Covid-19 pandemic, there has always been the need to provide support for the mathematics education of Filipino learners. The challenges of achieving the twin goals of mathematics education, as explicated by the Department of Education (2016) are well-documented (Bernardo & Limjap, 2012; Verzosa & Vistro-Yu, 2019). Although the twin goals of mathematics education are critical thinking and problem solving, mathematical learning in the Philippines is still characterized by rule-based

methods and rote memorization (Verzosa, 2020). Further, a large number of Filipino students perform poorly in mathematics assessments that demand higher levels of cognitive thinking (Schleicher, 2019). The problem was exacerbated by the Covid-19 pandemic where students were not with their teachers, and remote learning was mostly done through modules, especially in the areas without internet. In this connection, mathematical applications were developed by the math group of the project team. These were interactive, engaging, easy to use with limited supervision, and were designed to address learning competencies prescribed by the Department of Education. One venue of distribution for these mathematical apps is through the set-top box and can be easily downloaded by the parents and students.

The use of datacasting technology for educational delivery to under-resourced communities has already been trialed elsewhere. Recently, in the United States, due in part to the disruption of onsite classes brought about by the COVID-19 pandemic, SCETV, South Carolina state's public educational broadcasting network (South Carolina ETV, 2020), and Pennsylvania PBS, a public television organization (Pennsylvania PBS, 2020), have pioneered a pilot project to explore how the datacasting technology can address the digital divide by providing learning content to students without home internet access. Although datacasting is not meant to take the place of broadband internet, its potential to provide an equitable solution using a well-established technological infrastructure to access online educational materials without home internet connection is boundless.

2. CONCEPTUAL FRAMEWORK

2.1 RuralCasting

The RuralCasting system mainly utilizes Wi-Fi technology to distribute the educational resources that are normally unavailable to users without the internet. As shown in Figure 1, the set-top box can be accessed using any Wi-Fi device or using the set-top box itself as a stand-alone unit. When accessed through the Wi-Fi network, multiple users will be able to download, view, and stream the content made available offline. The content can also be updated periodically using the datacasting transmission.

The contents, namely, the applications, videos, text files, images will be locally stored in the set-top box. A lightweight learning management system like Moodle and Canvas but specifically for the RuralCasting set-top box, named *Edukastv* was created. In *Edukastv*, the content creators or teachers can upload their subject outline, reading modules, quizzes, etc. for the students to access.

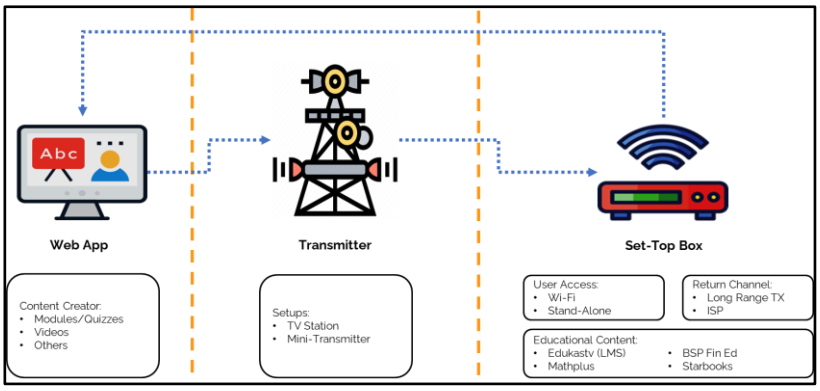


Figure 1. RuralCasting system overview

Users connect to the RuralCasting's Set-Top Box Wi-Fi network and will be able to access the RuralCasting Portal (Figure 2a). Once connected, the user can then navigate through the services hosted by the Set-Top Box, such as Edukastv, Math Applications, and videos on Financial Education produced by the Bangko Sentral ng Pilipinas (BSP). The Set-Top box also hosts an instance of DOST's Science and Technology Academic and Research-Based Openly Operated Kiosk (STARBOOKS) (Figure 2b).

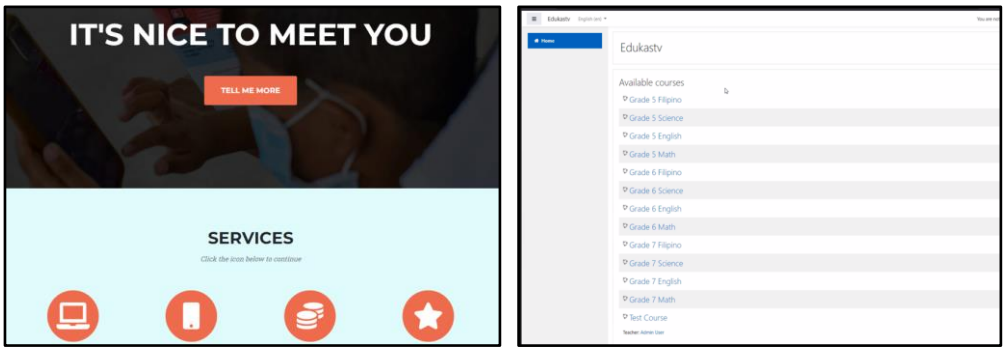
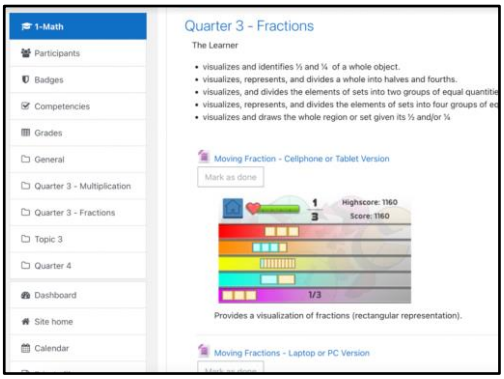


Figure 2. (a) RuralCasting Portal; (b) Edukastv page

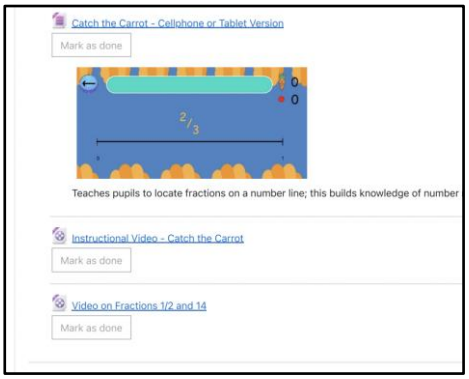
For the users to access the mathematical mobile applications, they will need to be connected to the set-top box's Wi-Fi, go to the rcast.local page, and navigate the portal to the Math Applications page. The page will display all the available mathematical mobile apps available for download. An instructional page is also available for the users shown in Figure 3.

Figure 3. Instructional guide in installing the mobile app

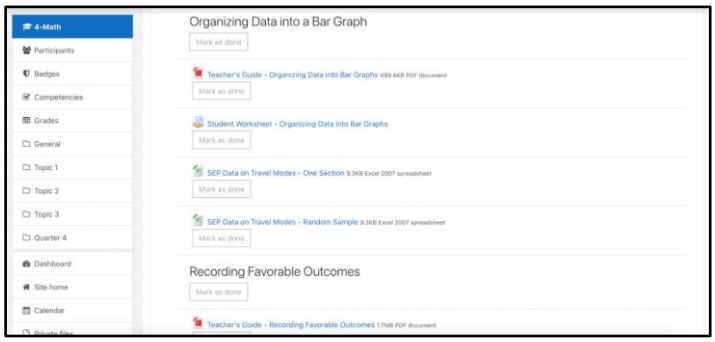
The teachers can incorporate the apps into their learning modules in Edukastv as shown in Figure 4(a). Since the mobile apps have been curated for the learners' grade level, the teachers will have an easier time in assigning the appropriate mathematical concept for their learners. Accompanying the mobile apps are other related resources such as teaching guides, student worksheets, or instructional videos that have been developed through the project. Examples or models for different grade levels on how the apps and these resources can be integrated and organized in Edukastv are also provided to the teachers as shown in Figure 4(b-c).



(a)



(b)



(c)

Figure 4. (a) Incorporating the mobile app in Edukastv; (b-c) Organizing mobile apps and other educational resources (e.g., videos, teacher's guide, student worksheet) in Edukastv

2.2 Mathematical Applications

The mobile mathematical applications have been designed and developed for Grades 1-6 but can also be used for Grade 7. The applications focus on place value, fraction number sense, and number sense strategies. All these concepts are tied to the understanding of number magnitude, which provides a unifying framework for mathematical understanding (Siegler et al., 2011). Examples of apps that have been developed by the project are *Catch the Carrot* (Verzosa et al., 2021a) and *Grid Game* (Verzosa et al., 2021b).

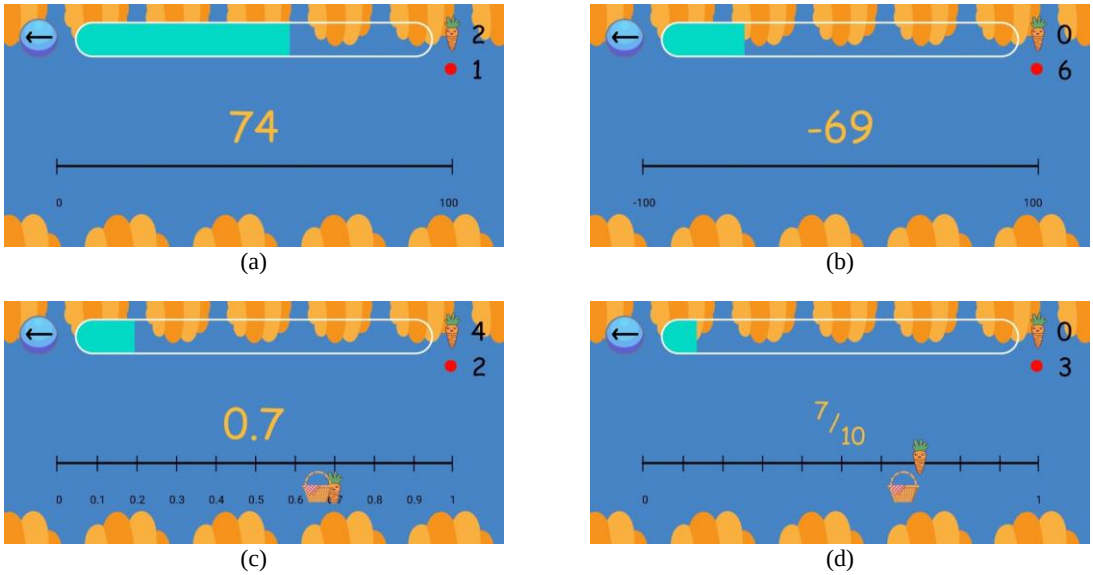
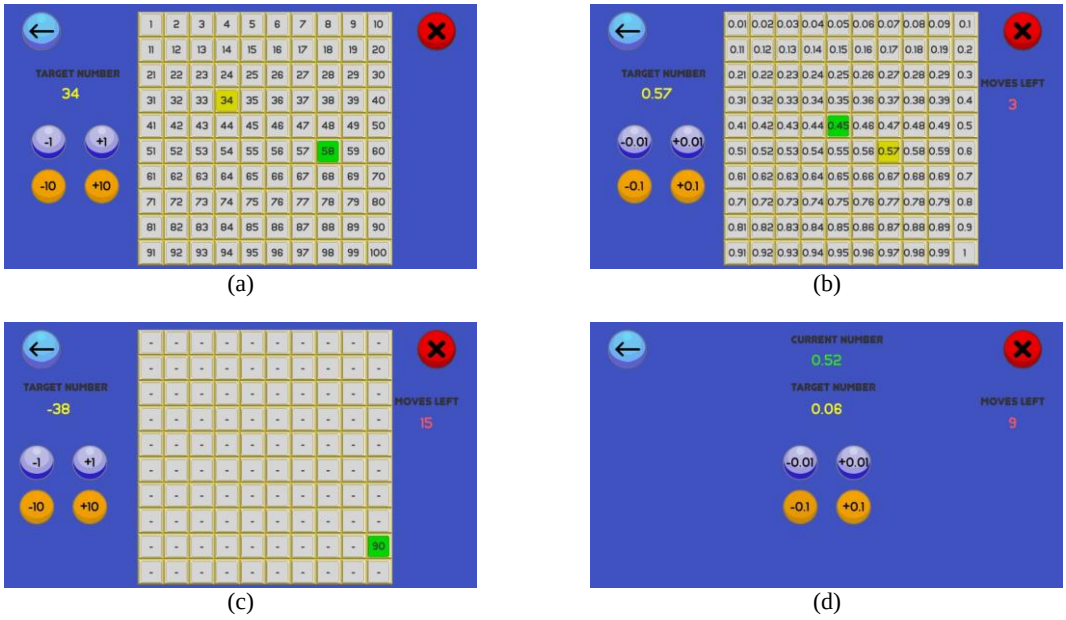


Figure 5. Screenshots of *Catch the Carrot* consisting of different levels such as (a) whole numbers, (b) integers, (c) decimals, and (d) fractions

Catch the Carrot is a number line mobile app designed to develop students' knowledge of whole number and fraction magnitude, which are important predictors of later mathematical achievement (Siegler, 2016). In the app, a segment of a number line is shown, and students need to estimate the location of a given number on the segment. For example, in Figure 5(a), the segment is from 0 to 100, and the given number is 74. The student then needs to indicate the location of 74 on the number line. After the student enters a response, by tapping or clicking on the number line, a carrot appears and falls into a basket if the student's estimate is close enough. Different levels and challenges are present in the app. Students may choose to play with integers (Figure 5(b)), decimals (Figure 5(c)) or fractions (Figure 5(d)).

On the other hand, *Grid Game* is an app aimed to develop conceptual place value (Ellemor-Collins & Wright, 2011). The app shows a starting number and a target number (Figure 6(a)). The student needs to click on the buttons so that the starting number reaches the target number. In higher levels, the student must perform the task in the minimum number of moves. There is also an option to work with higher levels of abstraction through a blank grid (i.e., a grid with no numbers) as in Figure 6(c) or through no grid at all (i.e., only the starting and target numbers are shown) as in Figure 6(d).

As further detailed by Verzosa et al. (2021a, 2021b), both *Catch the Carrot* and *Grid Game* are based on research in mathematical learning and are aimed to promote mathematical reasoning and visual thinking so that children can learn to think independently. Both apps also contain various levels to address official learning competencies across the elementary mathematics curriculum. Further, both apps have been designed with careful integration of educational game design principles. This has been intentionally done to maximize the apps' potential not only in the classroom or in online synchronous classes but also for students' independent and regular use. Specifically, *Catch the Carrot* has been designed following the Game-based Learning Design Model (Shi & Shih, 2015) where 11 interrelated game-design factors are considered. Meanwhile, the game design of *Grid Game* conforms to the Educational Games Design Model (Ibrahim & Jaafar, 2009), which focuses on game design, pedagogy, and learning content modeling.



(a) (b) (c) (d)

Figure 6. Screenshots of the *Grid Game* consisting of different levels such as (a) whole numbers, (b) decimals, (c) integers with a blank grid, and (d) decimals with no grid (for increased abstraction)

The full set of mathematical apps developed by the project can be found on the website https://mathplusresources.wordpress.com/. As is the case with *Catch the Carrot* and *Grid Game*, all the mathematical apps found therein have been developed based on research in mathematics education and with due consideration to their alignment to the official curricula of the Philippines' Department of Education (DepEd, 2020). The design and development of apps that are game-based or gamified also follow educational gaming principles that have been corroborated in literature on technology in mathematics education. All the grade school level apps found in the aforementioned website are included in deployments via the RuralCasting system.

3. METHODOLOGIES

The mathematical applications were deployed by the team to two elementary schools: San Andres Elementary School and Madilaydilay Elementary School in the province of Rizal, Philippines. Location was a crucial

component in choosing the schools; the team had to identify schools with low interference in television frequencies for RuralCasting. The deployment had the full support of the Department of Education School Division Office of Rizal, which facilitated the cooperation of school administrators and teachers. Community officials also provided assistance. Meetings were held between the project team and the officials of the school division office, and the school administrators and teachers for the onboarding process. The math project team met with mathematics teachers of both schools and gave them webinars on the use of the mathematical applications.

During deployment, the team devised instructions and scenarios where the participants will be able to access the services, and simultaneously browse and download the applications. The team then tested the maximum number of participants able to smoothly access, stream, and download the content from the RuralCasting set-top box. Also, after downloading the mathematical applications, feedback on the applications (Figures 5 and 6) were gathered. Improvements were done on the mathematical applications based on the feedback. For example, an opportunity for improvement shown in Figure 7 is the integration of audio feedback, which was later on incorporated into the app. Further, the lack of instructions was identified as a weakness. Thus, some video demonstrations of the application were made to accompany the application.

Figure 7. Sample SWOT analyses

4. RESULTS AND DISCUSSIONS

In Table 1, it is shown that issues arose when there were more than 15 devices connected and utilizing the Wi-Fi network simultaneously. The mathematical applications that were given for transmission testing in RuralCasting worked perfectly and were compatible with the set-top boxes (Table 2).

In Table 2, it is shown how the set-top box performs in terms of distributing the mobile mathematical applications with respect to the increase in participants. As shown, it is observed that the participants have no problems in downloading, installing, and using the application. But issues such as delays in downloading and awaiting the pop-up for the device were observed once more than 15 participants simultaneously accessed the custom set-top box. Fortunately, once fully downloaded, the application was successfully installed and was fully utilized.

Table 1. Maximum users, activities, and remarks per set-top box

No. of Participants	Wi-Fi Connected	Browsing	Streaming	Downloading	Remarks
5	5	5	5	5	all were able to connect, browse, stream, and download the available content
10	10	10	10	10	all were able to connect, browse, stream, and download the available content
15	15	10	10	10	all were able to connect, browse, stream, and download the available content
18	16	14	13	15	some were not able to connect, some had issues loading the webpage, some had difficulty in downloading the app

Table 2. Example of app performance with respect to participants and experience

MathPlus App	No. of Participants	Remarks
Catch the Carrot	10	app successfully downloaded from the set-top box, installed in an Android device, and used the app
	15	app successfully downloaded from the set-top box, installed in an Android device, and used the app
	18	not everyone successfully downloaded the app from the set-top box, others had a delay in the download, but once successfully downloaded the app was successfully installed and utilized
Grid Game	10	app successfully downloaded from the set-top box, installed in an Android device, and used the app
	15	app successfully downloaded from the set-top box, installed in an Android device, and used the app
	18	not everyone successfully downloaded the app from the set-top box, others had a delay in the download, but once successfully downloaded the app was successfully installed and utilized

5. CONCLUSION AND OUTLOOK

This paper discusses the deployment of a customized set-top box capable of distributing offline content thru Wi-Fi. The resources offered from the set-top box range from images and texts to videos and Android applications. The users have been able to connect their personal Wi-Fi devices successfully and to navigate through the RuralCasting Portal. The contents have been successfully downloaded, installed, and utilized simultaneously by up to 15 participants during the technical demonstrations in the targeted sites in Rizal, Philippines.

The deployment continues in the current school year, where more schools in remote areas in the Philippines are identified to have access to set-top boxes with more educational content. A point of consideration and improvement in the set-top box is the testing with the participants of the return channel feature that allows information to be returned to the teachers (e.g., grades, scores, feedback from explorations with apps). This will provide valuable information to the teachers, and thus offer a mechanism for an alternative communication system to these areas without internet access.

This school year as well, the Philippines' Department of Education is implementing a "back-to-basics" program in reading and mathematics as part of a learning recovery endeavor to address the serious learning gaps among school children who have been locked down and only learned remotely during the two years of the pandemic. The mathematical apps that have been developed in this project are envisioned to contribute towards this purpose. Part of the outlook for the school year is to conduct studies in the areas of deployment with respect to the effectiveness of the apps in addressing the learning of the students.

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REFERENCES

Bernardo A.B.I. and Limjap A., (2012). Investigating the Influence of Teachers' Pedagogical Beliefs and Reported Practices on Student Achievement in Basic Mathematics. 12th International Congress on Mathematical Education. Seoul, Korea.

Department of Education (DepEd), (2016). K to 12 Curriculum Guide: Mathematics. https://www.deped.gov.ph/wp-content/uploads/2019/01/Math-CG_with-tagged-math-equipment.pdf

Department of Education (DepEd), (2020). K to 12 Most Essential Learning Competencies with Corresponding CG Codes. https://commons.deped.gov.ph/K-to-12-MELCS-with-CG-Codes.pdf

Department of Information and Communications Technology (National ICT Household Survey 2019). https://dict.gov.ph/ictstatistics/nicths2019/

Eballa J. N. et al., (2022). RuralSync: Providing Digital Content to Remote Communities in the Philippines through Opportunistic Spectrum Access. 2022 IEEE Global Humanitarian Technology Conference (GHTC). California, USA, pp. 125-128.

Ellemor-Collins D. and Wright R., (2011). Developing Conceptual Place Value: Instructional Design for Intensive Intervention. Australian Journal of Learning Difficulties, Vol. 16, No. 1, pp. 41-63.

Ibrahim R. and Jaafar A., (2009). Educational Games (EG) Design Framework: Combination of Game Design, Pedagogy and Content Modeling. Proceedings of the 2009 International Conference on Electrical Engineering and Informatics (ICEEI 2009), Bangi, Malaysia, pp. 293-298.

National Telecommunications Commission (NTC), (2016). Memorandum Circular No. 02-03-206, ISDB-T Standards. https://ntc.gov.ph/wp-content/uploads/2016/MC/MC-No-02-03-2016-Attachment.pdf

Pennsylvania PBS, (2020). Datacasting. Retrieved 10/30/2020 from https://pennsylvaniapbs.org/datacasting/

Rusciano A., 2021. ATSC Datacasting Paves Way for Flexibility of ATSC 3.0 in Distance Education - ATSC: Nextgen TV. https://www.atsc.org/news/atsc-datacasting-paves-way-for-flexibility-of-atsc-3-0-in-distance-education/

Schleicher A., (2019). PISA 2018: Insights and Interpretations. OECD, Paris, France. https://www.oecd.org/pisa/PISA%202018%20Insights%20and%20Interpretations%20FINAL%20PDF.pdf

Shi Y.-R. and Shih J.-L., (2015). Game Factors and Game-based Learning Design Model. International Journal of Computer Games Technology, Vol. 2015, pp. 1-11.

Siegler R.S., (2016). Magnitude Knowledge: The Common Core of Numerical Development. Developmental Science, Vol. 19, No. 3, pp. 341-361.

Siegler R.S. et al., (2011). An Integrated Theory of Whole Number and Fractions Development. Cognitive Psychology, Vol. 62, No. 4, pp. 273-96.

South Carolina ETV, (2020). Datacasting. Retrieved 10/30/2020 from https://www.scetv.org/datacasting

Verzosa D.M.B., (2020). Pre-service Elementary Teachers' Reasoning in Introducing Multidigit Subtraction. International Journal of Mathematical Education in Science and Technology, Vol. 51, pp. 876-892.

Verzosa D.M.B. et al., (2021a). Development of a Gamified Number Line App for Teaching Estimation and Number Sense in Grades 1 to 7. Proceedings of the 29th International Conference on Computers in Education. Taoyuan, Taiwan, pp. 648-656.

Verzosa D.M.B. et al., (2021b). Using Mobile Technology to Promote Higher-Order Thinking Skills in Elementary Mathematics. Proceedings of the International Conferences Mobile Learning and Educational Technologies. Lisbon, Portugal, pp. 19-26.

Verzosa D.M.B. and Vistro-Yu C.P., (2019). Prospects and Challenges in Implementing a New Mathematics Curriculum in the Philippines. School Mathematics Curricula, pp. 207-226.