

RESEARCH ARTICLE

Growing Tree Model: An integrated approach to foundational learning during the COVID-19-induced lockdown

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Abstract

In Zimbabwe, the lockdowns prompted by COVID-19 caused learners to miss an average of six learning hours per week. Following this impact, the Higherlife Foundation introduced a digital learning program called the Growing Tree Model (GTM) to help foundational learners improve their literacy and numeracy skills with a specific focus on English writing, English reading, and mathematics. To evaluate whether there has been an improvement in their performance following the intervention, this study was quasi-experimentally designed by pairing and assessing pre-and-post-intervention scores of 145 learners. The paired samples assessment revealed that the GTM led to a 7% and 8% improvement in learners' English reading and mathematics performance, respectively. In contrast, their performance in English writing declined by around 2%. The results suggest that the GTM led to a statistically significant improvement in learners' performance in English reading and mathematics only, explained by a p-value of less than 0.05 ($p < 0.05$) in these two intervention constructs. It is, therefore, recommended that the: education ministry support the development and uptake of digital learning platforms beyond the crisis period; and, if possible, partner with the Department of Social Welfare to train caregivers on basic knowledge of early childhood development and operationalizing digital learning platforms since most of them facilitated learners in having growing tree lessons yet they are not skilled in that area. Furthermore, the teaching approaches for English writing in the GTM can be refined since the platform led to a decline in learners' performance in that intervention construct. This paper contributes to pedagogical literature on the intersection between foundational learning, digital educational tools, and learning under non-ideal conditions by showing what worked and what failed to work in the context of the GTM.

Keywords: Growing tree model; integrative approach; foundational learning; early grade learners, mediating tools.

1. Introduction and background

The Growing Tree Model (GTM) is a digital strategy designed to help Early Grade Learners (EGL) improve their numeracy and literacy skills during the COVID-19-induced lockdown. This study evaluates the impact of the GTM on learning outcomes. The COVID-19 pandemic is multifaceted and complex; it can be understood through various perspectives, including health, economic, political, educational, social, and religious viewpoints. Numerous invisible links relating to issues around COVID-19 are often underexplored since researchers are still making inquiries on this pandemic

that put the world to a halt. Particularly, the link between COVID-19 and the education system in Zimbabwe is under-researched and poorly understood (Chronicle, 2020; Muderere, 2020; Newsday, 2020; Riside, 2020). Substantial financial assistance was mobilized in response to the COVID-19 crisis. For example, the World Bank announced an investment of up to US\$160 billion for two fiscal years following the onset of COVID-19 to support recovery measures, including education-related initiatives (Lung, 2020).

Though details are still unclear, it is approximated that over 4.6 million children in Zimbabwe were left without access to education as the pandemic forced the country into lockdown and schools to subsequently shut (Riside, 2020; UNICEF, 2020). With each passing day, restricted access to schools saw children losing an average of six hours of learning per week, with those in the foundational phase affected the most because much of their learning is based on direct contact and limited use of digital platforms (UNICEF, 2020). Furthermore, it has been argued that EGL are active explorers of their environments and they learn and construct their knowledge by doing and discovering through engaging in games with their peers (Essa, 2014). So, COVID-19 deprived them of that opportunity to interact and exchange their experiences through playing games in educational environments, and somehow forced the adoption of digital platforms. In their quest to justify interventions such as the GTM, Moshiri, Gasasira, & Gijzen (2020) projected that EGL affected by the closure of schools could experience 3% lower income over their entire lifetime.

Before the pandemic, EGL were at even more risk, characterized by a shortage of educators and schools, and the prohibitive cost of accessing education. Commenting on the data extracted from the Education Management Information System (EMIS) of the Zimbabwean Ministry of Primary and Secondary Education (MPSE) for the period 2017–2019, the Higherlife Foundation (HLF) 5-year rolling plan for education revealed that the percentage of qualified teachers increased from 89.2% to 97.1% and from 71.1% to 85.4% at primary and secondary school levels, respectively, while the Early Childhood Development (ECD) level remained static at 58.4% (HLF, 2020a). This is clear evidence that even before COVID-19, Foundational Learning (FL) was already facing other challenges. Further, in the recent past, Maramba & Mazongonda (2020) conducted a formative evaluation of the acceptance and usage of digital learning platforms in Zimbabwe. Their study revealed that in as much as digital platforms have an inherent potential to transform the education sector and improve learning outcomes, challenges such as frequent power cuts, and lack of adequate internet facilities, training, and computer resources limit usage. Furthermore, Maramba & Mazongonda (2020) argued that the low uptake of digital educational tools is partly attributed to the fact that most accessible platforms are commercially available and most public schools do not afford them since they are imported from elsewhere; there are few locally developed platforms.

Working through Simba Education, HLF designed a foundational phase learning program to bridge the gap resulting from the inhibitive cost of access to digital learning platforms and the inability to have physical lessons due to COVID-19 safety protocols. Instrumental to this initiative was the development of a textbook known as the Growing Tree Book (GTB). The book provides a practical way of learning composed of different themes that incorporate numeracy and literacy content intended for FL. During the 2021 lockdown, a pilot intervention was rolled out and the GTB was distributed to 1375 EGL across the ten provinces of Zimbabwe. These beneficiaries were drawn from children's homes supported by HLF. Students who received the book were expected to attend the growing tree lessons held live on ZOOM or pre-recorded sessions on the growing tree portal. This study examines the effectiveness of the GTM in improving the learning outcomes of EGL using paired samples analysis, that is, before-and-after-intervention performance assessment. Measurement of this effectiveness is premised on the null hypothesis that there is no statistically significant change in learners' performance against the alternative hypothesis that there is a statistically significant improvement in learners' performance. This assessment is important in offering sustainable solutions to overcome teaching and learning challenges in crises. By taking an experimental approach to a

unique area of public goods provision, this study highlights important themes for critical interventions to improve educational outcomes. Perhaps, before characterizing the GTM, situating this study in existing literature, and discussing the design and outcomes of this evaluation, it is prudent to define the operational meanings of key terms used in this paper. It must be noted that the meanings given in this section serve as proxies for their usage in forthcoming sections. Specifically, four key terms have been singled out, not to overemphasize their importance, but to give readers a rough visual imprint of key issues discussed in this paper:

- FL is the first level of exposure to formal education in Zimbabwe composed of ECD, and the first two years of primary education (grade 1 and grade 2).
- EGL are children getting their first level of formal exposure to formal education. In Zimbabwe, EGL are normally children of the ages 4 to 7 years.
- GTM refers to a digital strategy used by HLF during the COVID-19-induced lockdown to develop a textbook designed to help EGL improve their numeracy and literacy skills.
- GTB is a textbook with English literacy and numeracy content ideal for EGL. This book served as a vehicle for implementing the GTM

2. Characterising the GTM

The GTM, through its GTB, provides EGL with literacy and numeracy content in setting the scene for the development and advancement of these skills later in their academic life. The GTM is based on a holistic approach of integrating educators, learning material, and caregivers, with the learner at its center. This approach encouraged continued learning in homes for Orphaned and Vulnerable Children (OVCs), accelerated learning, and assisted in dealing with learning losses brought about and exacerbated by the pandemic. It is based on HLF's programming philosophy, which emphasizes the importance of designing and implementing community programs that are transformational, catalytic, and sustainable. HLF is a social investment organization founded in 1996 in Zimbabwe with the initial intention of helping OVCs. It operates in many African countries including Lesotho, Burundi, and Kenya, investing in education, public health, rural transformation, and disaster relief.

Since its inception, HLF has been working hand-in-glove with the Ministry of Labour Public Service and Social Welfare's (MLPSSW) Department of Social Welfare (DSW) to support OVCs in registered children's homes. It must be noted that the National Action Plan for Orphaned and Vulnerable Children (NAPOVC) recommends that all OVCs who fail to get foster care or adoption arrangements be taken to homes registered with the DSW (HLF, 2020b). When this evaluation report was compiled, 100 registered homes accommodated 4138 children, with their distribution across Zimbabwe's ten provinces displayed in Figure 1. Out of this total, 1375 of them were at the foundational level and they all participated in the growing tree project.

According to the UNICEF Evaluation Report on NAPOVC 1 of 2010, homes faced numerous challenges related to the general upkeep for children in providing basic services such as nutrition, health, and education. So, the GTM placed specific emphasis on the education component; through its robustness, the GTM partly addressed challenges of access to quality education, poor literacy and numeracy skills, and underqualified early caregivers and teachers. Simba Education teachers delivered live online lessons using the ZOOM platform or pre-recorded the lessons. Students were registered through the HLF-supported homes. The GTB was distributed as a supplementary aid for teachers and caregivers. The online classes were structured into three age groups: ECD; grade 1; and grade 2. Interestingly, the GTM was designed with an offline capability to accommodate learners in remote parts of the country where access to the internet is a challenge. Are models of this nature peculiar to Zimbabwe or there are global experiences that can be likened to the GTM?

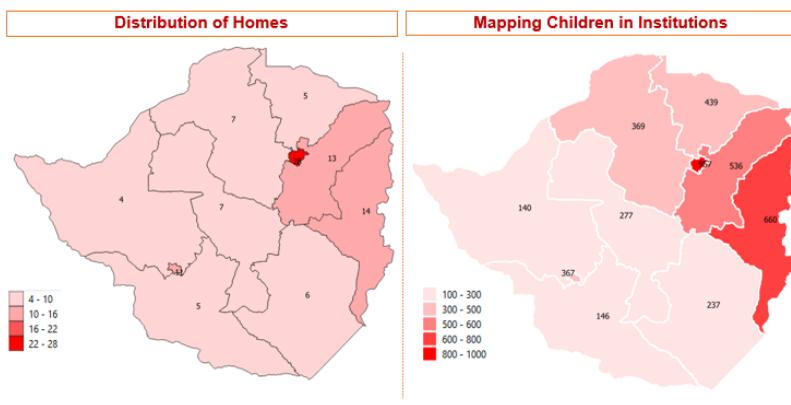


Figure 1. Distributions of children's homes in Zimbabwe (HLF, 2020b)

3. Literature review

The preceding paragraphs emphasized that the main concern of this study is to evaluate the impact of the GTM on the learning outcomes of EGL. In line with this objective, this section situates this study in the existing literature on digital learning programs and FL models by reviewing theoretical, conceptual, analytical, and methodological issues in accessible literature. This study is underpinned by the Cultural Historical Activity Theory (CHAT) which was first coined by Lev Vygotsky (1934,1978) and later developed by Leont'ev (1981). Central to the CHAT, mediating tools are critical in imparting and acquiring knowledge and skills. According to Hennig & Kirova (2012), mediating tools are tangible or intangible cultural artifacts such as symbols, signs, games, media, language, ideas, teaching methods, and social relationships. This thinking was recently reinforced by Wu, Cheng, & Koszalka (2021) who asserted that learners acquire knowledge from the environment through mediating tools. It can, therefore, be deduced that digital learning programs that embed indigenous content, by their nature as mediating tools, can enhance the mastery of literacy and numeracy skills by EGL since they assist in acquiring and transferring knowledge.

The CHAT is composed of six elements; subject, object, community, tools, rules, and division of labour. First, the subject is the person or people directly participating in a given activity system. In this case, the subjects are teachers who use the GTM as a mediating tool to teach EGL. Second, the object or intended outcome of an activity can be either tangible or intangible, reflecting the underlying motivation for people's participation. Third, it has been explained that the object is realized in the context of a community defined by a social group that subjects are a part of; children's homes in the context of this study. Fourth, within this social setting, just like in any system, there are explicit rules or social norms that regulate interaction. In the context of this study, the GTM is in between spaces regulated by the MLPSSW (in dealing with OVCs) and MPSE (in using the GTM to impart knowledge). Fifth, the interaction among individuals within the community brings about the division of labour. Tasks and responsibilities are shared among system participants as they engage in an activity; EGL, teachers, and caregivers are some of the participants who share responsibilities in the system. Sixth, the tool is an instrument used to drive an activity; this equates to the GTM in this case. Overall, the CHAT explains that teachers (subjects) use GTM (tools) to impart knowledge (object) in a given setting (community) governed by specific policies (rules), and in so doing, sharing of tasks is inevitable since there are many players in a community (division of labour) as summarized in Figure 2.

The diagrammatic summary shown in Figure 2 suggests that six constructs form the underlying infrastructure of the CHAT. These constructs can either be analyzed in their totality (using the

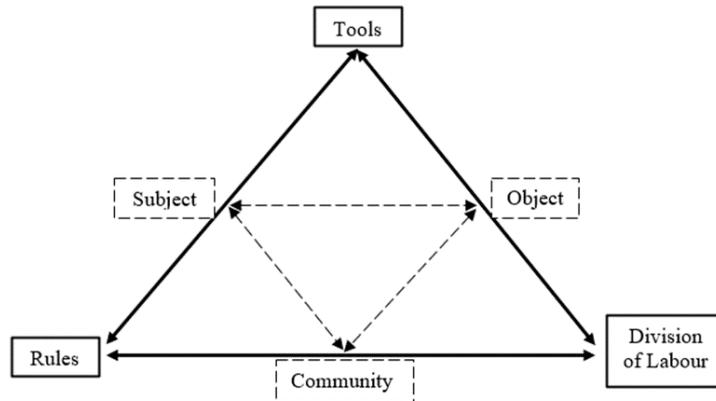


Figure 2. The dialogic nature of interactions (Engestrom, 2009)

entire triangle), or in smaller triangular sets (using 4 inner triangles), depending on the argument the analyst seeks to advance. In the context of this study, all six constructs have been adapted to give a fuller picture of the driving and restraining forces to the usage of the GTM in teaching literacy and numeracy competencies to EGL in children's homes. This approach has been justified by Johnson & Golombek (2011, p.9) who asserted that using all six constructs provides "...a framework that maps the social influences and relationships involved in networks of human activity". Overtones of the CHAT have some footprints in global experiences aimed at fostering numeracy and literacy competencies in EGL by using digital tools indigenous to different regions across the world.

In the recent past, Gasteiger & Moeller (2021) used case data drawn from 95 children from five kindergartens in Germany to carry out seven 30-minute training sessions over 4 weeks targeting 4-to-6-year-old children. The intervention sought to test if there is a statistically significant difference in understanding of math concepts between children who play conventional board games with traditional number dice and those who engage in games without numerical symbols. The intervention was designed using pre-and-post-test assessments to measure the effectiveness of the two approaches in fostering mastery of early numerical concepts in natural play situations. The study revealed that children who play board games with traditional dot dice are better off in counting and recognising structures, implying that such games are more effective in teaching numeracy skills. The study by Gasteiger & Moeller was adapted to the unique cultural characteristics of Germany, differentiating it from other interventions based on other countries' indigenous knowledge. Peculiar to Gasteiger & Moeller's study is the use of counterfactual evidence to evaluate the effectiveness of an intervention. That is, using before-and-after assessments on each of the treatment group (subjected to the use of a particular tool) and the control group (not subjected to the treatment), yet the present study uses the treatment group only (see the methodology). Although the study made a significant contribution, it was narrowly focused on numeracy skills, neglecting the development of literacy skills.

To address the challenges: "how to develop students' mathematical thinking and conception, how to increase student motivation to learn math, how to improve achievement in math, and how to maintain an interesting, enjoyable, and successful learning process in math", Fouze & Amit (2018, p.617) did a prescriptive analysis of ethnomathematical games native to the Negev Bedouin people of Israel in the Middle East. The authors used three different plays ('ta'ab-the stick game', 'mozkat-5 stone game', and 'seega game') to distinguish between an activity and a game and propose parameters for developing an ethnomathematical curriculum. In their prescriptive analysis, Fouze & Amit (2018) described each game with regards to the context it can be played, its underlying rules, and its alignment with mathematical principles. Two key lessons from Fouze & Amit's study are that individual countries

must develop or refine existing curricula to integrate cultural values native to them, and teachers must play an instrumental role in connecting learners with the content embedded in teaching tools. However, the study is largely descriptive, devoid of numerical backing or hard data to demonstrate the effectiveness of the three reviewed tools. Furthermore, the study was centered on the examination of the development of numeracy competencies only.

In a study entitled *“Black students’ rich mathematical experiences: Mathematics concepts and Xhosa cultural games for reception class”*, Feza (2019) argued for the decolonization of early-grade math education citing the inequalities brought about by colonization and apartheid in South Africa. It has been argued that the skewness of poor performance in mathematics towards black children has pushed the narrative that mathematics is for the elite and belongs to the West, ignoring one’s prior knowledge and experiences. This is premised on the belief that the development of numerical competencies is embedded in one’s cultural artifacts, but learners are not given that orientation from an early age due to mathematical exclusion characterized by language, racial, and economic segregation, all brought by colonization and its legacy inherited at independence. To this effect, Feza explored four cultural games played by Xhosa children, bringing to light their inherent potential for integration into pedagogy. Specifically, the study provided thick descriptions of how ‘*upuca*’, ‘*black toti*’, ‘*umrabaraba*’, and ‘*itreyini*’ games are played and the mathematical concepts embedded in them. Interestingly, Feza’s study recognized the role of teachers and language in infusing relevant cultural values into mainstream pedagogy. However, it is non-numerical, making it difficult to assess the impact of the described games in changing the learning outcomes of EGL. Furthermore, Feza’s study did not examine the effectiveness of teaching tools in the impartation of literacy competencies; where they were mentioned, they were meant to clarify the role of language in enabling the teaching of numeracy skills.

Collectively, the reviewed studies have demonstrated the importance of developing teaching tools native to a given society considering that knowledge production and learning are contextual. This long-running theme is in sync with the GTM that was developed in Zimbabwe, by Zimbabweans, to help EGL in Zimbabwe to acquire and master numeracy and literacy skills. It has also been observed that the effectiveness of a teaching tool revolves around the language used to design it; since the instructional language in Zimbabwean schools is English, the GTM partly addresses this requirement because it is structured in English. However, English is not the native language in Zimbabwe, bringing in a new twist to the whole saga; the need to use native language in developing teaching tools. In as much as this brings in an important debate, it is not this study’s concern to examine knowledge decolonization regarding instructional language. Furthermore, many of the studies on this subject are largely descriptive, with a greater inclination towards assessment of tools’ effectiveness in imparting numeracy skills. Consequently, this study fills this gap by providing a statistical evaluation of the impact of the GTM on EGL’s learning outcomes focusing on both literacy and numeracy skills. Perhaps the answers to how this study was conducted provide insight into how the identified gaps were addressed and the study’s objectives were achieved

4. Methodology

Inspired by the design of a somewhat similar study by Gasteiger & Moeller (2021), this study was quasi-experimentally designed with one group. It adopted a pre-and-post-test assessment of EGL who attended the growing tree lessons. The design sought to determine if there is a statistically significant difference between learners’ performance at two-time points (before and after using the GTM), with the view of proving or disproving the null hypothesis stated ahead of this study. So, following the advice given by Larson & Farber (2006) to use paired samples (also known as dependent or matched samples) on problems involving before and after results for the same person(s) or object(s), or results of individuals matched for specific characteristics, this approach was purposively selected for its relevance to the purpose of this evaluation; to assess the performance of the same learners at

different periods. Larson & Farber further noted that paired tests can only be performed when the involved population(s) is normally distributed. So, the pre-and-post-test datasets were tested for normality using the Shapiro-Wilk (SW) normality test in version 16.0 of the Statistical Package for Social Scientists (SPSS). The normality test was done to determine whether the data was normally or non-normally distributed based on the correlation between the data and the corresponding normal scores. Output from the SW normality test revealed that the data is normally distributed, supporting the use of paired samples. In this case, baseline data on learners' performance in English reading, English writing, and mathematics served as pre-test scores, and data collected after the pilot intervention, using baseline indicators, served as post-test scores.

It must be noted that this evaluation is not based on tests conducted by the researchers, but on the results availed to the researchers based on the tests conducted by Simba Education teachers since they were responsible for implementing the GTM. Both pre-and-post-test data were collected from the official record of marks of 145 learners based on Kazerooni's (2001, p.993) distinction between target and study population who clarified that "...a target population is the whole group of [individuals] to which we are interested in applying our conclusions. Unfortunately, the target population is not always readily accessible, and we can only study that part of it that is available. A study population, then, is the group of individuals or units to which we can legitimately apply our conclusions". Then, a sample denotes part of the study population that is assessed since it is, oftentimes, unmanageable to assess the study population in its entirety. In this case, the target population is 1375 since the GTM was piloted with 1375 learners. Since the researchers were based in Harare and Bulawayo provinces at the time of conducting the evaluation, they conveniently selected these two provinces and collected data from 228 learners who were part of the pilot intervention in these two provinces; as such, 228 served as the study population. Then, a sample size of 145 learners was established using Slovin's formula (Larson & Farber, 2006), calculated as follows:

$$n = \frac{N}{1 + Ne^2}$$

$$n = \frac{228}{1 + 228 \times 0.05^2}$$

$$n \approx 145$$

where:

n - sample size

N - study population e - margin of error

The sample was selected using a multi-stage sampling procedure: first, proportionate sampling was used to select the proportional number of participants per province and home; second, within the individual homes, children were systematically selected by picking every n th learner in the register. Then, SPSS version 16 was used to pair pre-and-post-test scores to determine their correlation and to test if the post-scores were significantly higher than the pre-scores. The paired samples t-test for statistical significance was carried out at a 0.05 level of significance.

To better understand some of the results generated from statistical analysis, in-depth interviews with seven caregivers representing each of the sampled homes were carried out. Since the interviews were in-depth and semi-structured, probing questions enabled the caregivers to comment without limit. Using Yin's (2018) advice that specifying and follow-up questions can be used to get clarity on specific issues raised by participants, the researchers attentively listened and interjected where possible to get the interviewees to clarify certain issues. In general, probing, follow-up, and specifying questions were employed to gain deeper insights into learners' performance and caregivers' experiences with the GTM. The next section discusses synthesized results following the comparison of pre-and-post-test scores.

5. Results and discussion

Synthesized results presented and discussed in this section are based on the pass threshold of 60% set ahead of the GTM. As such, gathered data on learners' performance was first converted into percentages and five categories were set as A(90–100%), B(80–89%), C(70–79%), D(60–69%), and F(0–59%). Overall, accessible evidence revealed that, despite the fluctuating performances between and within the three intervention constructs, the GTM significantly improved learners' literacy and numeracy competencies. The analysis of learners' performance presented and discussed in forthcoming paragraphs recognizes that the change in performance cannot be solely attributed to the GTM since numerous factors can determine one's performance. For example, the CHAT explained that changes in the learning environment, rules of engagement, teachers, and teaching tools and methods all shape one's performance. So, the results discussed in this paper are based on the 'ceteris paribus' assumption, that is, specific focus is placed on the tool (GTM) and all other determinants of performance are believed to be constant. Table 1 shows the frequency distribution of learners' performance per construct according to the grading system set ahead of the intervention.

Table 1. Frequency distribution of learners' performance

Grade	Pre-Scores			Post-Scores		
	Reading	Writing	Maths	Reading	Writing	Maths
A (90-100)	11	11	18	39	8	38
B (80-89)	10	10	42	11	11	27
C (70-79)	31	31	11	43	39	20
D (60-69)	65	65	12	38	59	21
F (0-59)	28	28	62	14	28	39
Totals	145	145	145	145	145	145

In line with the three intervention constructs, data shown in Table 1 can be broadly grouped into three pairs of English reading, English writing, and mathematics since this study was designed using paired samples. Each pair is composed of pre-and-post-test scores. It is prudent to discuss the per-construct change in performance before assessing the statistical significance of the identified change to give a data profile of learners' performance and condense the dataset into a few summary measures and visual aids. Figures 3 to 5 show multiple bar graphs for English reading, English writing, and mathematics, respectively. It must be noted that in each bar graph, blue and red bars represent the pre-test and post-test scores, respectively.

Figure 3 shows that within the first three categories (A, B, and C) of English reading, there is a positive change in learners' performance since the post-test scores have higher bars than the pre-test scores. After the intervention, learners were redistributed across various performance categories. For example, the number of learners in the A category increased by approximately 400%, followed by a small increase in the number of learners in categories B and C as signified by a small difference in the heights of their bars. Then, the number of learners in the two bottom categories, D and F, dropped by approximately 50%. This could be partly explained by the redistribution of learners to categories A, B, and C, showing the positive contribution of the GTM to learners' ability to read. Studies by Feza (2019) and Fouze & Amit (2018) explained that using new learning tools may take a considerable time to translate into positive results as both learners and educators adjust. Contrary to that conclusion, the GTM super-normally catapulted learners' ability to read during the pilot intervention as exhibited by the redistribution of their performance towards higher grades.

Since there are fluctuating reading scores across the grades set ahead of the intervention, it is prudent to assess the overall change within these fluctuations. In line with this consideration, it was revealed that there was a 9.7% increase in the number of learners that performed above the threshold

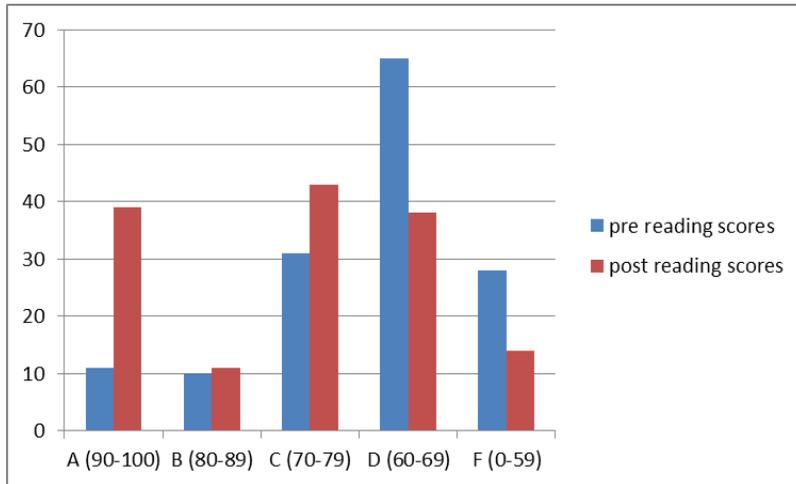


Figure 3. Multiple bar graph showing pre-and-post-test reading scores

of 60%. This indicates the important role played by GTM in providing quality education. One caregiver noted that learning to read is difficult for children who cannot recognize letters or associate them with their sounds. This sentiment may apply to learners in the D and F categories; probably they were indirectly excluded by the GTM. This finding is supported by Feza’s (2019) observation in South Africa that exclusionary models negatively affect the capacity of EGL to utilize language and understand the meaning of spoken and written words as this is linked to letter reading, writing, and spelling proficiency. There is also a general convergence of ideas among scholars that EGL who exit the FL phase with low literacy skills fall and stay behind, resulting in poor academic accomplishment, high dropout rates, and, in some cases, a lifetime of hardship (Koszalka & Wu, 2021; Feza, 2019; Fouze & Amit, 2018). This is premised on the belief that the first decade of every child sets the scene for later stages in life (Gasteiger & Moeller, 2021; Moshiri, Gasasira, & Gijzen, 2020). Could this revealed pattern be the same as the one for writing scores?

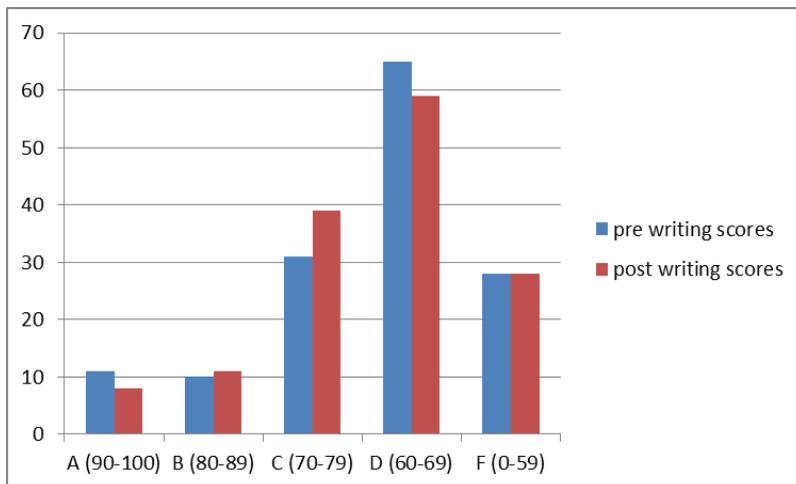


Figure 4. Multiple bar graph showing pre-and-post-test writing scores

Writing scores shown in Figure 4 gave a pattern contrary to the reading scores. For example,

the number of learners in the A and D categories slightly decreased despite the exposure to the GTB content, while the number of learners in the B and C categories slightly increased. In both cases, despite the difference in the direction of change, the degree of change is very small since the heights of the bars are almost the same. Then, the number of learners in the class of low performers (F category) remained static despite the intervention. The static number of learners in category F can be likened to the category of learners who used board games without numerical symbols in Gasteiger & Moeller' (2021). However, generalization of these comparable results is suspect on the count of different areas of focus, English writing and numeracy competence.

During the narrative inquiry, one participant revealed that the key point of emphasis in the GTM is developing the ability of learners to write their names. It was further explained that learners must also be able to write the alphabet without missing any letter. This also entails being able to write the alphabet in both uppercase and lowercase letters without changing fonts. As the learners approach the age of seven, they should no longer reverse the letters of the alphabet (for example, 'b' and 'd'). The gathered data suggest that, overall, there was neither an increase nor decrease in the number of participants that reached the 60% threshold. So, Figures 3 and 4 have shown that, although both English reading and writing seek to drive literacy competencies, the two constructs have different outcome patterns. Does the pattern of change in numeracy skills follow any of the reading or writing patterns, or it has a peculiar pattern?

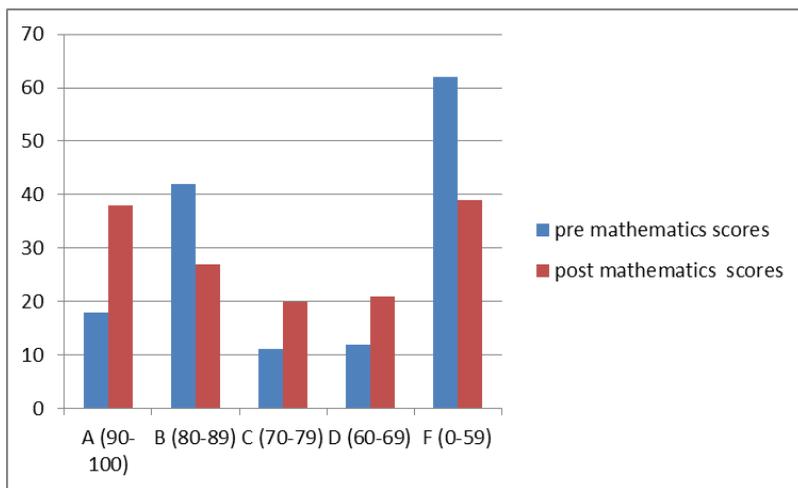


Figure 5. Multiple bar graph showing pre-and-post-test math scores

The change in learners' performance in mathematics somewhat follows a pattern that can be likened to that of English reading. For example, there was an increase in the number of learners in three out of five performance categories (A, C, and D), each recording an approximately 100% increase. Then, each of the B and F categories recorded an approximately 60% decrease in the number of learners. Despite the fluctuating performance in numeracy competencies as shown in Figure 5, there was an overall 15.8% increase in the number of learners that could recognize numbers 0 to 9. This was a critical aspect of the intervention since number recognition and associated skills are critical in early education. The ability to recognize numbers in base 10 (that is, 0 to 9) gives a strong foundation for developing counting skills, as is supported by Gasteiger & Moeller's (2021) conclusions based on case data from Germany. Such similar results may be partly attributed to the fact that both studies used play-based methods to help learners improve their numeracy skills. The bar graphs in Figures 3 to 5 have given a rough visual imprint of the pre-and-post scores of learners, setting the scene for the quantitative description of the change in their performance using measures

of average and measures of spread summarised in pairs in Table 2.

Table 2. Descriptive summary of learners’ performance

Paired Samples	Summary Results				
	Mean	N	Std. Dev	Std. Error	height
Pair 1	Pre-reading scores	65.0823	145	17.99286	1.49423
	Post-reading scores	72.3034	145	20.77834	1.72555
Pair 2	Pre-writing scores	65.0552	145	17.43352	1.44777
	Post-writing scores	63.4690	145	19.42187	1.61290
Pair 3	Pre-math scores	61.8000	145	27.23957	2.26212
	Post-math scores	70.2207	145	23.69173	1.96749

The study revealed that the mean performance of learners in English reading and mathematics went up by approximately 7% and 8%, respectively, while that of English writing went down by approximately 2%. All other factors being equal, this suggests that the GTM negatively impacted learners’ writing skills. This could be partly attributed to the approach used in GTB that confused learners, leading to a drop in performance. One classical philosopher, Todd Haynes, said ‘...every actor comes with their own experience, method, methodology’. One could argue that analyzing established performance through these philosophical lenses can lead to new approaches and methods that either enhance or hinder one’s performance. This is in sync with the explanation given by the CHAT that the design and nature of mediating tools (GTB), and the subject (teacher) responsible for connecting learners with the object (literacy and numeracy skills) they need to master are critical components in the impartation and acquisition of knowledge. As such, whenever there is a change in approach, two probable effects are expected; either an increase or decrease in performance. Further analysis was done to determine the strength of the association between pre-and-post-test scores. Correlation analysis was considered important since it has been argued that results generated by paired samples are more credible and powerful if there is a strong correlation between pre-and-post-test scores (Larson & Farber, 2006). The results of the correlation analysis for each pair are shown in Table 3.

Table 3. Correlation of paired results

Paired differences	Correlation analysis output		
	N	Corr. Coef	Sig
Pair 1 Pre-and-post reading scores	145	0.695	0
Pair 2 Pre-and-post writing scores	145	0.857	0
Pair 3 Pre-and-post math scores	145	0.767	0

Correlation coefficients shown in Table 3 suggest that there is a strong positive association (with a correlation coefficient of at least 0.7), with varying degrees of strength, for each of the three pairs under study. In terms of strength rank, English writing comes first, followed by mathematics, and tailed by English reading. Furthermore, it was established that the relationship between each pair is statistically significant ($p < 0.05$) implying that the GTM played an instrumental role in changing the performance of EGL. Similarly, a study on the effectiveness of board games played with traditional number dice and board games played without numerical symbols by Gasteiger & Moeller (2021) resulted in strong positive correlations between pre-and-post-test scores. Using such outcomes for further analysis, arguably, guarantees the conclusive power of a study (see Gasteiger & Moeller, 2021; Larson & Farber, 2006). Having established the correlation between the paired results, further analysis to test whether there is a statistically significant difference between pre-and-post-test performance

of learners was carried out and outcomes of the paired samples t-test are shown in Table 4.

Table 4. Pre-and-post-test mean difference in performance

Paired Samples	Summary Results			Confidence interval		Paired sample testheight		
	Mean	Std. Dev	Std. Error	Lower	Upper	t	df	Sig. (2 tailed)
Pair 1: Pre-and-post reading scores	-7.221	15.365	1.276	-9.743	-4.699	-5.659	144	0
Pair 2: Pre-and-post writing scores	1.586	10.035	0.833	-0.061	3.233	1.903	144	0.059
Pair 3: Pre-and-post Maths scores	-8.421	17.718	1.471	-11.329	-5.512	-5.723	144	0

The results summarised in Table 4 show that on average, for English reading, the post-test scores are 7.2 points higher than the pre-test scores (95% CI [-9.74, -4.70]), and for mathematics, the post-test scores are 8.4 points higher than the pre-test scores (95% CI [-11.33, -5.51]). Contrary to English reading and mathematics, on average, for English writing, the post-test scores are 1.6 points lower than the pre-test scores (95% CI [-0.06, 3.23]). It has also been revealed that there is a statistically significant mean difference between learners' pre-and-post-test results for English reading and mathematics ($p < 0.05$), while there is no statistically significant change in performance in English writing ($p > 0.05$). As such, the results for English reading and mathematics reject the null hypothesis, while the one for English writing fails to reject the null hypothesis. This implies that the GTM edified learners' performance in English reading and mathematics but does not result in a statistically significant change in learners' performance in English writing. In as much as there is an overall negative change in English writing (see Table 2), the change is not statistically significant, that is, it is reasonably low without noticeable effect.

Juxtaposing these results with Gasteiger & Moeller's (2021) results in terms of statistical significance, the significant change in English reading and mathematics can be likened to games played using boards with traditional number dice, whilst the insignificant change in English writing can be likened to games played with boards without numerical symbols. The similarity in the change in numeracy competencies can be traced back to the use of play-based approaches in both interventions. It is also critical to note that the two studies have different sample sizes, where Gasteiger & Moeller used a sample size of 95 whilst the present study used a sample size of 145. Furthermore, Gasteiger & Moeller's study used counterfactual evidence where pre-and-post-test assessments were simultaneously applied to two groups (treatment and control), whereas the present study used pre-and-post assessments to one group only. So, the weakness of the present study in terms of the design, that is the absence of counterfactual evidence, has been partly compensated by the use of a large sample size.

Evidence also showed that, during the intervention, digital skills were transferred to both learners and caregivers. One caregiver noted that it was their first time participating in digital interactive learning. Due to the availability of classes on demand, the GTM proved effective for students who needed remedial learning. A significant percentage of learners (at least 60%) who used the GTB identified drawing exercises and colouring as some of the outstanding features of the model as was narrated by one caregiver. These features are critical in developing writing and other skills including fine motor coordination and accurate finger grip in children. Caregivers living with learners in homes played a key role in helping them complete their daily exercises. More than 90% of the learners received help from either caregivers or older siblings in their homes.

The success recorded by the GTM pilot intervention is a true testimony that the use of digital platforms at the foundational level is feasible under both ideal and non-ideal conditions. This program might have been developed for non-ideal conditions (COVID-19-induced lockdown), but it can be refined and perfected based on lessons learned so that it can be effectively used to positively influence learning outcomes of EGL under both ideal and non-ideal conditions. So, the MPSE and its partners such as HLF must support the pro-active development of learning models such as GTM, rather than reacting to challenges when they show up. The GTM could have realized an even higher success rate if it was prepared way ahead of time, having adequate time to pre-test and pilot-test it before its adoption. Emergencies, by their nature, demand rapid response and swift actions, some of which

might not be the best possible options. So, this is a wake-up call to the stakeholders in education to invest in digital platforms to complement the traditional direct contact approaches.

The outcomes of this study also provide lessons to the DSW responsible for overseeing the operations of children's homes. The study has revealed that untrained caregivers were at the forefront of assisting learners in taking growing tree lessons and doing activities embedded in the GTB. Some of them revealed that it was their first time to use digital educational platforms. So, they were learning simultaneously with the learners, but with an additional role to facilitate and supervise the learning process as Simba Education teachers were delivering the lessons. So, the MLPSSW, through its DSW, must venture into a partnership with the MPSE to give caregivers basic training on ECD and operating digital educational platforms since they provide first-hand support to learners when they are away from school. Viewing this through the lens of CHAT, caregivers working in homes are part of the community responsible for the co-construction of knowledge. Overall, this paper provides details on the innovative strategies that can be used during large health shocks and other disasters to provide basic education to EGL and other levels of learners in general. Essentially, it outlines what worked and what failed to work during the intervention and provides lessons on what can be done to ensure that interventions of this nature realize their stated and implied purpose.

6. Closing reflections

In assessing the effectiveness of the GTM, a digital learning platform designed for EGL during the COVID-19-induced lockdown, in improving learning outcomes, this study used paired samples of learners' pre-and-post-intervention scores in English reading, English writing, and mathematics. Learning outcomes for English reading and mathematics improved due to the intervention, whereas learners backslid their performance in English writing. From prior research, it has been noted that EGL effectively learn when they engage in play-based activities or cultural games among themselves; this allows them to co-create knowledge as they interact and network as children, with teachers helping them connect with numeracy and literacy skills in the process. This approach to learning requires direct contact yet COVID-19 came with a complication inhibiting learners from acquiring knowledge the conventional way, forcing the use of digital platforms such as the GTM that limit their interaction and networking. Going forward, the MPSE must support the development and uptake of digital learning platforms beyond the crisis period since this study has revealed that such approaches are effective in imparting English reading and mathematical skills. Furthermore, in partnership with the MPSE, the MLPSSW, through its DSW, must prioritize the training of caregivers to get basic knowledge of ECD and the use of digital learning platforms since they facilitate and support learners in having virtual tuition. To the developers of the GTM, there are prospects for refining teaching approaches for English writing since their platform led to a decline in learners' performance in that intervention construct. The limitations of this study around the research design and monomaniac focus on mediating tools can be addressed by having future studies focus on: using counterfactual evidence drawn from sampling units not exposed to a given treatment and comparing results of the control and treatment groups; and having broad studies that assess the role of other determinants of educational outcomes. The CHAT has explained that there are six determinants to the change in learning outcomes, yet this study placed much emphasis on one determinant, mediating tools. Where other determinants such as the subject, object, rules, community, and division of labour were mentioned, they were meant to clarify and specify certain issues, despite the growing emphasis given by scholars such as Feza (2019) and Fouze Amit (2018) on the key role played by the subject (teachers), the community (caregivers), rules (educational policies), and object (numeracy and literacy content) in determining learning outcomes. This paper contributes to pedagogical literature on the intersection between foundational learning, digital educational tools, and learning under non-ideal conditions by showing what worked and what failed to work in the context of the GTM.

Biography notes

Simbarashe Show Mazongonda is a Freelance Researcher and Monitoring and Evaluation Specialist with over a decade of experience conducting project surveys and implementing interventions for global organizations, including OXFAM GB and USAID. He has also worked with Econet's Higherlife Foundation, where he played a key role in designing, implementing, and monitoring projects across sectors such as health, rural development, education, women and girls' empowerment, and disaster relief. He is currently completing his PhD at the University of Lodz, Poland.

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