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ORIGINAL ARTICLE

Development and Application of FOCUS App for Assessment of Approaches to Learning in 3–8-Year-Old Children in Kenya: A Design-Based Research Approach

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Abstract

Performance-based tools to assess school readiness domains such as Approaches to Learning are lacking in Low and Middle-Income Countries such as Kenya. This study aims to develop the Kenyan version of the FOCUS app (Finding Out Children's Unique Strengths), a game-like computer tablet assessment of two Approaches to Learning domains: mastery motivation and executive functions. We used a design-based research approach to develop and validate the FOCUS app, initially designed for the US and Hungarian Cultures, to suit the Kenyan context. We later followed children longitudinally from preschool to grade 1, to assess the applicability of the FOCUS app to the two grade levels. Results showed that the FOCUS app is valid and reliable. There was no significant difference in mastery motivation between the two waves. The FOCUS App can complement other school readiness tools to assess Approaches to Learning as one of the strategies to enhance school and life success.

Keywords Approaches to learning · Assessment · Design-based research · FOCUS app · Mastery motivation

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Introduction

Studies have established that school readiness predicts both school and life success; therefore, its precise assessment is critical (Russo et al., 2019). Furthermore, children who progress to kindergarten with fewer school readiness skills show lower school achievement throughout schooling (Burchinal et al., 2015). In addition, poor school readiness is linked to later criminality, unemployment, and academic failure (Pelletier & Brent, 2002). Although there are many tools for assessing children's learning and development, few are suitable for Lower and Middle-Income Countries (LMIC), since most of them were normed in high-income western countries (Pisani et al., 2018). However, there are a few inexpensive tools that have been validated and used in the LMIC contexts. One tool for assessment of psychomotor development, specifically eye-hand coordination and locomotor skills, for children below three years was developed in Kilifi-Kenya, the Kilifi Developmental Inventory (KDI; Kitsap-Wekulo et al., 2016). The KDI is suitable for identifying patterns of typical and atypical psychomotor development; however, it does not assess other areas of development and is limited to children under 3 years of age.

For children over 3 years of age, several tools are available that can be used to evaluate child development programs, including the Early Childhood Development Index (ECDI), created by UNICEF. Another tool for 3.5 to 6.5-year-olds is the Early Development Index (EDI; Janus & Offord, 2007), which is a teacher-report, classroom-based tool used in schools. Assessment at the classroom level limits its use in populations that are outside the school system, however, which is problematic currently given that 61 percent of children in developing countries are still out of school (UNESCO, 2016). A similar initiative is the Measuring Early Learning Quality and Outcomes (MELQO) that was led by UNESCO in 2014 to evaluate the existing tools and develop a holistic measure of both learning and development in pre-primary children (UNESCO et al., 2017). MELQO has been piloted and validated in many LMICs including Tanzania (Raikes et al., 2019). Additionally, International Development and Early Learning Assessment (IDELA; Pisani et al., 2018) was developed under Save the Child Foundation. IDELA is an open-source, holistic, and adaptable tool suitable for program evaluations and their improvements inside and outside school environments. The majority of the tools mentioned above are paper-based and suitable for program evaluations but not individualized feedback to parents, teachers, and children, to inform individualized support programs in the classroom. Apart from IDELA and MELQO, which directly collect data from children, the others are filled out by parents and teachers on behalf of the child, and there is evidence that adult reports are not direct measures of child characteristics (e.g., Rothbart et al., 2001). Moreover, IDELA only assesses four domains: socio-emotional, numeracy, motor, and literacy but not Approaches to Learning, an important domain of school readiness, which is the focus of the current paper.

Approaches to Learning are rarely assessed directly in children as a part of school readiness assessments, even though it has been found to be a crucial

predictor of later school performance (Józsa et al., 2017; Kagan et al., 1995). Approaches to Learning (ATL) is an umbrella term for attributes that help children learn: enthusiasm, persistence, motivation, interest, flexibility, initiative, self-regulation, reflection, attentiveness, cooperation, and independence (Li et al., 2019). These attributes form an essential domain of school readiness (McDermott et al., 2014). In general, school readiness assessments emphasize cognitive factors that are phenotypically similar to academic performance, such as emergent literacy and numeracy, rather than socioemotional school readiness or ATL (Li et al., 2019). However, ATL, such as perseverance when faced with challenging tasks and the ability to hold problems in mind and solve them creatively, have been documented to be important for both the academic performance and socioemotional development of children (Hunter et al., 2018).

Children's enthusiasm, persistence, and focus on challenging tasks can be viewed as indicative of their mastery motivation. Mastery motivation is the urge or psychological "push" to solve problems, meet challenges, and master ourselves and our world (Barrett & Morgan, 2018, p4). The focus of most mastery motivation research has been on children's engagement with objects and tasks during learning, persistence when solving moderately challenging tasks, and/or engaging with adults and peers while trying to master cognitive tasks and or social interactions (Józsa, et al., 2020). In addition, some research has focused on affective mastery motivation, the emotions experienced while trying to master or just after mastering tasks (e.g., Józsa & Barrett, 2018). All of these are important for successful adjustment to school and ability to benefit from the school environment, which is why mastery motivation is considered important to school readiness (Józsa & Barrett, 2018; Józsa, et al., 2020). In addition, neuroimaging results have shown that executive functions (EF) components, namely inhibition, working memory, and cognitive flexibility, are also critical in learning. Several authors have identified both mastery motivation and EF as critical components of Approaches to Learning (e.g. Józsa & Barrett, 2018). Surprisingly, mastery motivation is rarely assessed as a dimension of school readiness, and existing tools for assessing mastery motivation as a school readiness attribute are parent or teacher report instruments (Józsa & Barrett, 2018). Moreover, studies that examine students' persistence rarely describe this attribute as motivation (Torgrimson et al., 2021). However, it is important to study students' motivation, given studies showing that children from low Socio-Economic Status (SES) are at risk for lower mastery motivation and academic skills (Garcia et al., 2019). It is important to find out why children from lower SES are at risk for low mastery motivation, which requires strong measures of mastery motivation. Since mastery motivation is malleable and students from low SES stand to benefit the most from such interventions, accurate, individualized measurement of mastery motivation is needed, to enable intervention with individualized strategies to improve mastery motivation in early childhood to help close SES gaps in both mastery motivation and achievement(McDermott et al., 2014).

Executive functions (EF) are additional ATL that have been repeatedly found to be significant predictors of school performance (e.g. Amukune & Józsa, 2021) also see Cortés Pascual et al. (2019) for a review. Müller and Kerns (2015) define executive functions as the cognitive processes that are required for the conscious,

top-down control of action, thought, and emotions, and which are associated with neural systems involving the prefrontal cortex. EFs are divided into three principal processes: inhibitory control, working memory, and cognitive flexibility. All of these processes are important for school success (Cortés Pascual et al., 2019). As will be described shortly, some tools for measuring EF in young children in LMIC have been developed (e.g., Howard & Melhuish, 2017; Willoughby et al., 2019). However, these existing measures do not meet the needs of LMIC because they rely on platforms not widely used there. Moreover, mastery motivation, which is also important, has no similar assessments for LMIC. Both mastery motivation and EF play a critical role in the preschool to school transition (Blasco et al., 2014), and it is important to assess them together because children who have the capacity to use EF may fail to do so if they are not motivated to master the challenging tasks involved. Similarly, a child could be very motivated to master a challenging task but might show low focus in trying to master the task because they do not have the EF skills needed to do so.

In the current study, the specific ATL assessed were mastery motivation and EF, and both were assessed using the same child-based app. These two constructs are essential components of ATL, which lay a foundation for academic achievement and school success (Józsa et al., 2017). Nevertheless, very few studies have included both of these constructs in the assessment of ATL, and, to our knowledge, none have done so in sub-Saharan Africa. Mastery motivation is important in preschool training since it is related to skill development and predicts school achievement, math, and language skill development (Mercader et al., 2017) and is positively correlated with social competence (Józsa & Barrett, 2018). The seminal report, "From Neurons to Neighborhoods" identified mastery motivation as a particularly critical component of child growth and development that should be assessed during child evaluations (Shonkoff & Philips, 2000).

Assessment of Approaches to Learning

Different methods have been used to assess ATL, such as teachers' reports, parent reports, and direct assessment (Li et al., 2019). The critical mastery motivation construct has almost always been assessed using parent and/or teacher reports, given the paucity of easily administered, psychometrically robust assessments. However, direct assessments of EF that have been validated in the LMICs do exist. Executive function Touch (EF Touch) is a structured laptop computer tool designed for 3–5 year old children that administers eight EF tasks: Bubbles, Arrows, Houses, Silly Sounds Game, and Something's the Same, Pig, Pick the Picture, and Farmer. Arrows and Pick the picture have been validated and used in Kenya (Willoughby et al., 2019). Limitations of this method include its use of a laptop rather than an android app, requiring internet access and usually use of a mouse rather than a touch screen, as well as its being normed on only 3–5-year-old children. This is problematic in the current Kenyan environment, in which 3 out of 10 preschool children,

especially those in rural areas, are over age (Uwezo, 2021). In addition, this assessment does not include games to measure mastery motivation.

Another similar tool validated in South Africa is the Early Years Toolbox (EYT); a free-to-use digital application assessing early self-regulation, executive function, language, and social-emotional development (Howard & Melhuish, 2017). The iPad tablet-based app uses the "Mr. Ant" task to assess visual-spatial working memory, the EYT "not this task" to assess phonological working memory and the EYT Go/No-Go task assesses inhibition. Just like the FOCUS app, this task requires participants to perform tasks based on auditory instructions. Despite the EYT's suitability for the LMICs it does not assess mastery motivation and is not android based, the platform that is used by the majority of telephone and tablet users in the LMICs, especially in Kenya.

Therefore, although two tools for assessing EF in LMICs do exist, neither measures mastery motivation, and the assessments require hardware and software that often are not available in LMIC and/or are not appropriate for the full age range of the early learning population in Kenya. In practice, when ATL is assessed at all, typically parent and/or teacher ratings are utilized, and it is unclear the extent to which such rating accurately reflects the child's abilities. Additionally, the majority of these adult-report tools have also been normed in western countries. They include the Preschool Learning Behaviors Scale (PLBS; McDermott et al., 2002), Child Behaviour Rating Scale (CBRS), and the Approaches to learning scale of the Early Childhood Longitudinal Study-Kindergarten Cohort's ECLS-K (Li-Grining et al., 2010).

The value of parent and teacher reports depends on the quality of information teachers and parents can produce. Characteristics of the teacher or parent, such as implicit bias or parental beliefs: and/or practical difficulties, such as insufficient opportunity to carefully observe individual children in relevant contexts and/or memory error, are some of the challenges that reduce the validity of adult ratings as measures of the real behavior of the child (Rothbart et al., 2001). Consequently, direct, child-administered methods have been suggested to compensate for these weaknesses. The majority of LMIC have relatively little access to trained examiners who can administer individual, direct assessments. A form of direct assessment that could be administered without the need for intensive training of examiners is a narrated, self-administered, computer tablet-based method. However, to date, we are not aware of any tablet-based assessment of both mastery motivation and EF that has been used in Kenya. To fill this gap, we have been re-designing, developing, and testing a game-like android-based tablet app called Finding Out Children's Unique Strength (FOCUS; Józsa et al., 2017) that fit the Kenyan context.

Research Objectives

The objectives of this study are threefold: (i) Re-design, develop and adapt the FOCUS app, following the design-based research approach, to suit the Kenyan context. This approach is relevant in this study due to the bigger objective of involving preschool teachers, to encourage them to adopt FOCUS during school-readiness tests and intervention with children with low academic achievement. (ii) Determine

the psychometric properties of the newly adapted app; (iii) Determine stability (test–retest) of FOCUS in a longitudinal study of children in two waves, from preschool to grade 1.

Materials and Methods

Research Design

To adapt FOCUS to fit the Kenyan context we utilized the design-based research approach (DBR). DBR aims to inform practice, develop research grounded theory, and revise existing designs by incorporating requirements of all stakeholders, including researchers, experts, and beneficiaries within a real-world problem or intervention. DBR has three interrelated stages: (a) analysis and exploration; (b) design and construction; (c) evaluation and reflection (McKenney & Reeves, 2014).

Analysis and Exploration

The main activities of this phase are to specify the educational problem at hand, its context, and the stakeholders involved (McKenney & Reeves, 2014). In the context of cross-cultural adaptation, these cover the first five steps in the process of planning proposed by Fischer and Poortinga (2018). In the first instance, we identified the problem to be addressed in Kenya. The Kenyan educational system acknowledges the need for and uses school readiness assessments (Republic of Kenya, 2017). Unfortunately, although ATL is acknowledged as essential to school success, currently, there is no attempt to enhance the learner's motivation and EF in the preprimary curriculum. This suggests a need to enhance the Kenyan curriculum to address these school readiness domains and accurately measure whether or not there is growth in the domains. This information supported the potential benefit of developing a tool to assess ATL for Kenyan students. We, therefore, composed a multidisciplinary team of developmental psychologists, curriculum developers, Swahili and English language experts, teachers, ICT professionals, and other stakeholders. These experts participated in several stakeholder meetings at different stages of the project.

We also carried out document analysis to find out if preschool teachers assessed ATL during the transition to grade 1. Our effort to get documentary evidence of ATL assessment was not successful, due to poor record-keeping. However, the evidence we obtained from other sources indicated that areas of ATL, including mastery motivation and EF, are not currently included in preschool school readiness assessments in Kenya and require urgent intervention. Therefore, in the third stage, we identified our target psychological constructs as two components of ATL: mastery motivation and executive functions. We also carried out structured interviews with preschool teachers who attended school-based training at one of the national universities in the Coast region. This was followed by another set of interviews with County Education officers, parents, and curriculum experts to establish how school

readiness is assessed in preschool and what interventions are taken to remediate any deficits.

As expected, results showed that teachers rarely directly assess or report on the child's ATL. One teacher reported to us during the interviews, "We train the children, but interviews to join grade one are done by grade 1 teachers who never taught them, and they do not share with us the questions nor the results". A further interview with the County Early Childhood officer revealed that teachers have not yet been trained to use the new Kenya School Readiness Test, indicating that most teachers are not competent on how the tool is completed and interpreted. Additionally, the tool does not have a section on motivation or executive functions; the assessments are basically on academic skills. Apart from stakeholder meetings to discuss how ATL is assessed and its context variables, we also carried out an intensive literature review of school readiness domains. From the literature, we anchored our study in the theory of approaches to learning (Kagan et al., 1995). From stakeholder meetings and literature search we agreed that a form of direct assessment that could be administered without the need for intensive training of examiners is a narrated, self-administered, computer tablet-based method. Since the objective of the study is to develop a tool to assist during individualized school readiness assessments, our sample was based on schools and the unit of analysis was the individual children from different schools. Additionally, we wanted to examine how the items functioned in the Kenyan context. Using G*Power 3.1.9.4, the sample size of 84 was big enough to yield a medium effect size at a power of 80% and an alpha level of 0.05 for correlation and regression tests.

Design and Construction of FOCUS App

The aims of this phase are first to adopt a systematic procedure that will generate solution(s) to the identified problem (design) and chart clarifications as design principles that can be used in the future (McKenney & Reeves, 2014). Next, construction entails the creation of prototypes that exemplify these design ideas. This phase is similar to the sixth step of the planning process of "operationalizing the theoretical predictions" (Fischer & Poortinga, 2018, p. 704), To inform the design and construction, we carried out a scoping review of literature of similar apps used in the assessment of school readiness domain (Amukune et al., 2022). For assessment of mastery motivation and executive functions as components of ATL, we only found one app—the FOCUS app, which was initially designed for Hungarian and American cultures (Józsa et al., 2017).

The FOCUS app is designed to evaluate three competencies: pre-academic skills, mastery motivation and EFs. To measure these competencies FOCUS has a total of seven tasks. Task 1 and 2 assess the accuracy of recognition of numbers and letters, the two pre-academic skills measured. Tasks 3–5 are letter and number search tasks that are designed to assess mastery motivation, operationalized as the child's persistence during moderately challenging tasks. Children are asked to find all copies of a specific letter or number in an array. Tasks 6 and 7 are tasks primarily designed to assess EFs, but Task 6, Picture Memory, also can provide a measure of mastery

motivation. Tasks 3 through 7 are measures of ATL. Since data are collected individually by the tablet as each child completes the tasks, the results on each school readiness domain can be profiled for each child. This will allow for individualized remediation and enrichment efforts by the teacher and parent (Józsa et al., 2017).

Construction to Fit Kenyan Context

We analyzed the curriculum content for preschool in Kenya to see how the content of the FOCUS app is or is not relevant to current pre-primary educational practices. We first explored the suitability of the original American English version to assess if it would be suitable for the Kenyan context. All the research team members agreed that the American English accent would be challenging to understand for the Kenyan preschoolers. We, therefore, decided to use two versions of the narration; Swahili and English versions both narrated by a female teacher with a Kenyan accent.

To achieve cultural equivalence, the team also replaced Little Bear, which is the narrator, with "Little Puppy". The bear is an animal that is unfamiliar to Kenyan culture, and which has no simple Swahili name for the children. This was done to suit the Kenyan culture better and avoid bias caused by cultural-based specifics (Peña, 2007). We also replaced "bunny" with "rabbit," which is more familiar English terminology in Kenya. We followed International Testing Commission guidelines (Gregoire, 2018) to translate the English version of the FOCUS app to Swahili and later back-translated to English. To achieve language and functional equivalence, the

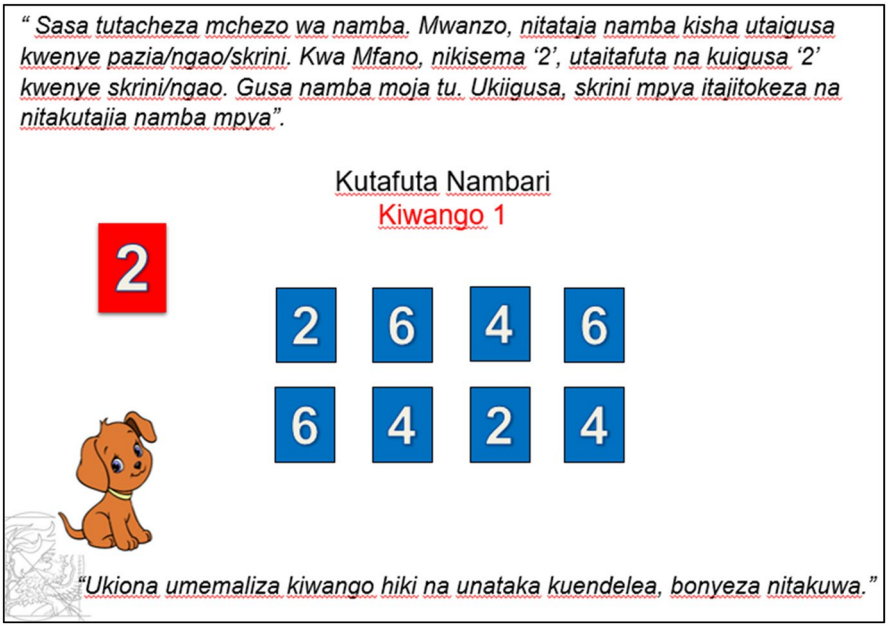

Fig. 1 A screenshot of the newly adapted FOCUS app in Swahili. Note: A little puppy has replaced the original little bear, and the narration is in Swahili

back-translated version was compared with the original English version to ensure originality is maintained. Since the narrator provides instructions to be undertaken by the child in the same way to all the children, the influence of different interpretations is reduced (Peña, 2007). Figure 1 shows one of the screenshots of the newly adapted FOCUS app in Swahili to fit the Kenyan context.

Next, we randomly recruited five children and three teachers from three preschools and gave them the audio content from FOCUS to listen to in Swahili. Three children came from a poor background in a rural setting and two from a private school in an urban setting. All the children spoke Swahili at home and school with a little English and had very little exposure to tablets. Before the exercise began children were shown examples of phones, tablets, and laptops to ensure they were familiar with these devices. When the child was comfortable with the tablet and the narrator 'little puppy', the child was set aside for the exercise. Understandability was judged based on the ability of the learners to undertake the task as per the instructions of the audio (Kotani et al., 2014).

Evaluation and Reflection

This phase entails data collection, data checking, and analysis (Fischer & Poortinga, 2018). After the design and development were complete, we tried the FOCUS app with a small subsample of 15 children, and 3 experts in IT and system administrators. Two errors were detected in the pre-academic skills tasks and corrected.

Study 1: Pilot Study to Validate the Newly Developed FOCUS App in Swahili

Participants

After getting the Institutional ethics review approval and authority to conduct the study in Kenya, we stratified preschools into private and public and recruited preschool children in the last term in pre-primary II in the rural areas of a large coastal county of Kenya using stratified random sampling. Only 9% of the children came from private schools and the rest from public schools. In the rural areas of Kenya, the majority of children attend public schools, however, in major cities like Nairobi and Mombasa, the two major cities, more children attend private schools than public schools (Willoughby et al., 2019). We randomly recruited 103 children in the third term of pre-primary 2; 8 failed the first training task and 6 had less than 10% of the data recorded and were removed from the sample. The final sample included 89 children, whose ages ranged from 60 to 132 months, with a mean age of 77 months (SD = 1.09). Out of the 89, 47(53%) were boys and 42 (47%) girls. According to the Kenya National Early Childhood Policy (Republic of Kenya, 2017), the expected age is five years. Unfortunately, after the promulgation of the New Constitution, in 2010, Kenya declared free primary education. This has attracted all the children who had dropped out of preschool or had other challenges in attending preschool, and they began studies in preschool if they had not attended preschool, regardless of the child's age. In this sample, only 17 children (19.1%) were within the expected age

range of 5 years. The majority of children in the study area also attend preschool when they are much older than the expected school-going age, especially in public schools. Since Swahili is predominantly spoken, 81(91%) students preferred the Swahili version of FOCUS, while only 10(9%) preferred the English version. The children predominantly speak Swahili both at home and school. At the time of the study, the children were typically developing and of Kenyan origin. Their parents were mostly subsistence farmers with the majority having only completed primary school education.

Instruments

The main tools of assessment were: the Preschool Dimensions of Motivation Questionnaire DMQ-18, an adult-report measure of mastery motivation (Morgan et al., 2020), and the FOCUS tablet app (Józsa et al., 2017).

Procedure

Before using the tablet measures, teachers rated the pupils using the preschool DMQ-18. The DMQ-18 includes an adult-report measure of cognitive persistence similar to the directly assessed mastery motivation measures in the FOCUS app and was administered to assess concurrent validity/construct validity. Since we did not include measures of concurrent validity for EF in this initial study, we will limit our discussion of psychometrics to the assessment of mastery motivation by FOCUS. The FOCUS session began with the researcher filling in the login screen with a user identification and password. After filling in the child's age and gender, the researcher gave each child an anonymous ID number. After setting these details, the child was allowed to proceed with the experiment.

Data Analysis Strategy

The first two tasks on the FOCUS app, number recognition, and alphabet recognition, were used to measure pre-academic school readiness. The number of items answered correctly on each task was transformed into a percentage correct score and compared using paired sample *t*-test, to see whether Kenyan pre-schoolers showed higher performance in pre-reading or pre-math readiness. To determine item difficulty, the percentage of participants who responded correctly to a particular item of that age was obtained (Peña, 2007). The time spent on the moderately challenging letter search and number search tasks (in seconds) was captured and the average across the two tasks constituted the mastery motivation score. The moderately challenging tasks were developed based on data from the Hungarian sample. The average time spent persisting on each of the two moderately challenging tasks was later standardized ($M = 1$, $SD = 0$) to get the individualized moderately challenging computer score (IMCC). Then, these scores were correlated with one another and with results of the DMQ, as well as being used to predict performance in first grade.

In addition, stability and grade level-related change in number recognition, alphabet recognition, and mastery motivation were assessed.

Results

Pre academic Skills

Task 1 and 2 of FOCUS assessed number and alphabet recognition. Both number and alphabet recognition had 15 items each. The reliabilities for number and alphabet recognition were high: Cronbach's alpha were 0.84 and 0.94, respectively. Moreover, the paired sample *t*-test indicated that the performance of number recognition (M = 47, SD = 20.21) and letter recognition (M = 69, SD = 20.21) tasks were significantly different at $\alpha = 0.05$, $t\ (86) = -7.45$, $p < 0.001$, with the alphabet being recognized to a greater extent than numbers. Items 14 and 15 in number recognition were the most difficult for 60–70 months children with a paltry 6% and 4% respectively getting it correct.

Mastery Motivation and Competence on Letter and Number Search Tasks

We calculated three computer-generated scores for the letter and number search tasks. These were; Computer-generated time spent attempting the letter or number search task, which we called Time Spent Persisting (TSP); Percentage of Matching Symbols Found (PMS), and Computer Search Competence score (CSC). TSP is considered the central measure of mastery motivation, and the other two scores are measures of competence on the tasks, which can be used to gauge how difficult each task is for the child. Comparable scores have been used with the Hungarian and American English versions of FOCUS, so these scores indicate whether these tasks are appropriate for the Swahili Version of FOCUS. TSP is important as a measure of mastery motivation because it shows the time spent persisting not only while succeeding, i.e. correctly matching the numbers or letters, but also while attempting to match numbers or letters and making errors (Ventura et al., 2013). Table 1 shows the time spent attempting both number and alphabet search across four tasks that are assumed to range in difficulty for the children, based on work with children in

Table 1 Average time spent persisting during number and letter search tasks in seconds

Age in months	N	Number search				Letter search			
		Difficulty levels				Difficulty levels			
		Easy	MC1	MC2	Hard	Easy	M1	M2	Hard
60 to 70	17	48(21)	47(21)	68(46)	65(23)	36(28)	51(26)	52(31)	51(35)
71 to 84	46	62(26)	53(23)	71(88)	108(132)	35(23)	80(103)	60(51)	82(59)
85 or more	26	61(29)	88(61)	123(118)	119(109)	67(45)	62(45)	62(44)	86(59)

MC1 Moderately challenging 1, *MC2* Moderately challenging 2, SDs are in parentheses

Table 2 Computer search scores for number search and letter search tasks

	Number search % correct (SD)					Letters search % correct (SD)			
Age in months	N	E	MC1	MC2	H	E	M1	M2	H
60 to 70	17	74(24)	66(17)	62(15)	55(13)	70(23)	62(17)	60(14)	53(5)
71 to 84	46	67(22)	66(20)	65(20)	64(18)	76(23)	65(20)	64(16)	55(8)
85 or more	26	68(21)	66(18)	64(16)	61(15)	83(23)	67(19)	62(16)	56(13)

Note. E = Easy, MC1 = moderately challenging 1, MC2 = Moderately challenging 2, H = Hard; SDs are in parentheses

Table 3 Internal Consistency of letter and number search tasks

Reliability	Computer-based scores			Preschool motivation questionnaire (DMQ 18)		
	CSC	PNMC	TSP	TCP	TMP	TNR
Cronbach's alpha	.854	.748	.824	.708	.915	.852
NL Correlation	.492	.246	.794	–	–	–

($N = 89$) *CSC* Competence on the search tasks, *PMNC* percentage of non-matching cards found, *TSP* Time Spent Persistence on the four tasks assumed to be moderately challenging, *TCP* Teachers' Rating of Cognitive Persistence on the DMQ 18, *TMP* Teachers' ratings of Mastery Pleasure on the DMQ 18, *TNR* Teachers' ratings of negative reaction to failure on the DMQ 18, *NL* number search-letter search

other countries of the same age: (1) easy (2) moderately challenging 1 (3) moderately challenging 2 and (4) hard. Generally, the time taken increased across the tasks from easy to hard in the older age groups for both tasks, but it increased only for letter search for younger children, perhaps indicating that number search was too challenging for younger children at the medium and hard levels.

Computer Search Competence Score (CSC)

CSC is the average percentage of the letters or numbers that were matched correctly, taking into account those that were not matched correctly, i.e. errors, for all difficulty levels. For example, if a student matched correctly 60% of the cards and failed to match accurately 40% (i.e. errors), then the CSC will be computed as (60 + 100–40)/2. Table 2 shows that generally, the CSC declined from the easy to hard tasks in both number and letter search tasks.

Table 4 Correlation of the different FOCUS measures with each other and with the DMQ

	1	2	3	4	5	6
DMQ Persistence						
IMCC Persistence	0.357**					
PMS	0.208*	0.509**				
PNM	0.137*	0.110	0.483**			
CSC	0.303*	0.498**	0.793**	- 0.151		
Pre-academic skills	0.079*	-0.016	-0.147	- 0.339**	0.070	

DMQ Dimensions of Mastery Questionnaire, IMCC persistence = the average time spent moderately challenging tasks, *PMS* Percentage of Matching Symbols Found (PMS), *CSC* Computer Search Competence Score (CSC), *PNM* Percentage of Non Matching Cards found

* $p < .05$, ** $p < .01$

Reliability

Internal consistency reliability (Cronbach's alpha) was computed for the FOCUS measures Time Spent Persisting (TSP), Percentage of Matching Symbols Found (PMS), and Computer Search Competence Score (CSC), as well as for cognitive persistence as rated by teachers using the preschool motivation questionnaire, DMQ 18, see Table 3.

The reliability values shown in Table 3 were between 0.7, which is good, to 0.9 excellent. Average correlations between the number and letter search tasks were also calculated for the three computer-based scores. These correlations ranged from low to very large according to Cohen's (1988) criteria, and all three were significant.

Validity

Prior research has provided preliminary support for the validity of the English and Hungarian language versions of FOCUS when used with U.S. and Hungarian samples (Józsa et al., 2017). As a first step toward validating the Kenyan English and swahili versions with a Kenyan sample, we (1) correlated mastery motivation scores from FOCUS with those from the teacher- report DMQ-18, administered separately (concurrent validity), (2) correlated mastery motivation scores from one type of FOCUS task with that measure during another type of FOCUS task (concurrent validity) (Table 4); (3) analyzed how well the game assessment predicted a future outcome it was expected to predict.

Concurrent Validity

To examine the concurrent validity of the computer-based assessment tasks, the time during which the child remains focused on the two moderately challenging tasks on number and letter search was standardized (M = 1, SD = 0) to come up with

an individualized moderately challenging computer score (IMCC). This score is a measure of cognitive persistence. IMCC correlated positively with the cognitive persistence subscale of the Preschool Dimensions of Mastery Questionnaire (DMQ) 18, $r = 0.33$, $p < 0.001$ providing evidence for concurrent validity.

As a second method of measuring concurrent validity, mastery motivation on the search tasks was correlated with mastery motivation on the Picture Memory tasks. To assess mastery motivation from Picture Memory tasks, each child received one task that was expected to be easy, one expected to be medium, and one expected to be difficult for that child at that age. The time taken to complete the picture memory task was correlated with Time Spent Persisting (TSP) in the number and letter search task. IMCC correlated positively with persistence on the Picture Memory Tasks, $r = 0.535$, $p < 0.002$ providing further evidence for concurrent validity (Table 4).

Predictive Validity

A simple linear regression was also calculated to predict pre-academic skills in grade one based on the average time spent on moderately challenging tasks (IMCC persistence) as an independent variable and the percentage score of the sum of letter and number recognition tasks as the dependent variable. A significant regression equation was found F (1, 84) = 10.879, $p < 0.001$ with $R^2 = 0.115$ again providing evidence for predictive validity.

Study 2: Stability of the Newly Developed FOCUS App

In this phase, we tracked 89 children that participated in study 1 in the following year when they were joining the elementary school.

Participants

Out of the expected 89 children (47 boys and 42 girls) in preschool, we were able to locate 51 children (30 boys and 21 girls) in the next year immediately after the end of year vacation in different schools. The remaining 38 were either retained in preschool, dropped out, or their parents transferred them outside the County. The children had a mean age of 6.53 years (SD = 1.19) minimum age was five years, and the maximum was ten years.

Procedure

The session began with the researcher filling in the login screen with user details. After filling in the child's age and gender, the researcher gave each child a unique and anonymous ID number. The tablet language was set according to the teacher's preferred language of daily classroom instruction. After these details were set, the child was allowed to proceed with the experiments.

Results

The results showed that there was no longitudinal growth between waves 1 and 2 in mastery motivation, as measured by IMCC, but, unfortunately, there was a significant difference in letter recognition, with fewer letters being recognized at Grade 1 compared with preschool level (Table 5). Although correlations between performance at wave 1 and wave 2 were all significant, they were low to moderate in size, suggesting that although there was some stability of individual differences in mastery motivation and pre-academic skills (particularly number recognition), there was also a change.

Discussion

Our idea of recording both in English with a Kenyan accent and Swahili worked very well for the children. This allowed them to freely choose the language of their choice. In a similar study by Willoughby et al. (2019) in Kenya, results indicated that there was no significant difference in task performance, whether the tasks were presented in Swahili or English. However, many of the children in this sample had very low levels of proficiency in English, so we believe it was better for them to use the language in which they had greatest proficiency and comfort. Therefore, the feasibility of using this application for measuring school mastery motivation was good. The percentage completion rate was exceptionally high of over 80% in pre-academic and mastery motivation tasks, which was similar to Józsa et al. (2017) for Hungarian children. However, compared to Hungarian children in number, letter recognition, and average time spent persisting; the Hungarian children, on average, spent half of the time the Kenyan children took despite their advanced age. Additionally, for the computer search scores, on average, there was a 20% difference in scores between Hungarian and Kenyan children. This was mostly attributed to a lack of familiarity with tablets as a form of assessment. Reliability values for FOCUS tasks were all above threshold indicating that it was reliable in the Kenyan context. Criterion validity was also confirmed by mastery motivation scores on FOCUS correlating positively with the preschool DMQ 18 cognitive persistence subscale in the range of moderate to high moderate, which is similar to findings for Hungarian children of 0.35–0.57 (Józsa et al., 2017). Furthermore, the face validity of computer-based tasks is also much higher compared to the adult-report measures of persistence since it measures behavior in real-time (Ventura et al., 2013). The results of study 2 showed that there was no change in number recognition from preschool to grade 1, and that letter recognition declined. This could be due to the long vacation before the start of the school year indicating that children in this study rarely review their school work at home. Regardless, these findings support the need for intervention to help children maintain their knowledge and increase it further. FOCUS also showed one-year stability for mastery motivation tasks, although the correlations were small to moderate in size (Cohen, 1988). Importantly, mastery motivation at preschool significantly predicted letter and number recognition at grade

Table 5 Stability of FOCUS App assessment of children's pre-academic skills, mastery motivation, and executive functions

Constructs		Pre-school May 2019 Wave 1($N=89$)		Primary School January 2020 Wave 2 ($N=51$)		t	r
		M	SD	*M*	*SD*		
1	Pre-academic skills Number recognition in %	47	20.21	45.36	26.53	0.356	0.424**
	Letter recognition in %	69	20.21	54.12	32.68	2.571*	0.233*
2	Mastery motivation TSP in Sec	77.47	57.46	64.82	51.33	0 .712	0.301*

1st wave = 5–6 years, 2nd wave = 6–7 years. Paired *t*-test used to examine stability

TSP Time Spent Persisting; *IMCC* Individualized moderately challenging computer score

* $p<.05$, ** $p<.01$, *** $p<.001$

1, suggesting that it is a useful part of school readiness assessments. Although there was no significant difference in mastery motivation between the two waves, as noted, there was no attempt to improve mastery motivation integration in the Kenyan curriculum. Several studies (e.g. Józsa et al., 2020; Mercader et al., 2017) have shown that there is a correlation between mastery motivation and academic skills. Mastery motivation is malleable, and children from low socio-economic status benefit most from interventions (McDermott et al., 2014).

Conclusion

Initial feasibility tests of the FOCUS app have shown that it is valid and reliable to assess the pre-academic skills and mastery motivation, especially for Swahili and English preschool speakers. The availability of such an app in Swahili will fill a large void in Kenya and Africa in general since over 150 million people speak Swahili. Assessment of mastery motivation and EF will also help the teachers and parents in predicting ATL and planning possible intervention strategies. Assessment of academic achievement alone is not enough for school success. We strongly recommend that preschool assessments also measure non-cognitive skills such as mastery motivation and plan intervention strategies as a long-term measure to address school and life success. FOCUS app is a useful complement to other school readiness tools such as Early Years Toolbox and Kenya School Readiness Test in Kenya.

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