JOURNAL ON EDUCATION IN EMERGENCIES

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Author(s): Jasmine S. Turner, Karine Taha, Nisreen Ibrahim, Koen I. Neijenhuijs, Eyad Hallak, Kate Radford, Hester Stubbé-Alberts, Thomas de Hoop, Mark J. D. Jordans, and Felicity L. Brown

Source: *Journal on Education in Emergencies*, Vol. 8, No. 1 (March 2022), pp. 76-109

Published by: Inter-agency Network for Education in Emergencies

Stable URL: http://hdl.handle.net/2451/63607

DOI: https://doi.org/10.33682/8v7u-q7y3

REFERENCES:

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A PROOF-OF-CONCEPT STUDY OF CAN'T WAIT TO LEARN: A DIGITAL GAME-BASED LEARNING PROGRAM FOR OUT-OF-SCHOOL CHILDREN IN LEBANON

Jasmine S. Turner, Karine Taha, Nisreen Ibrahim, Koen I. Neijenhuijs, Eyad Hallak, Kate Radford, Hester Stubbé-Alberts, Thomas de Hoop, Mark J. D. Jordans, and Felicity L. Brown

ABSTRACT

Evaluations of education technology (ed tech) interventions in humanitarian settings are scarce. We present a proof-of-concept study of Can't Wait to Learn, a digital game-based learning program that combines an experiential, active learning design with meaningful, competency-appropriate, and contextually relevant content. We assessed the feasibility of using this program to address the current education gap in Lebanon by implementing its mathematics component in basic literacy and numeracy classes (n=30) with out-of-school children (N=390) ages 10-14. We estimated changes in numeracy competency and psychosocial wellbeing and conducted focus group discussions (n=16) and key informant interviews (n=19) with children, facilitators, parents, and partner staff members to understand the lived experience, perceived impact, and implementation challenges of the program. Our findings support the feasibility of using ed tech programs to meet the needs of out-of-school children, as we saw significant improvements in numeracy, psychological symptoms, and self-esteem; positive reported experiences with the program; increased motivation among the children; and overall ease of implementation. Our suggested improvements to the game design and implementation model will support ongoing program adaptation and implementation, with the goal of increasing access to quality education for children living in humanitarian settings. Our findings will inform future studies that seek to conclusively determine the program's effectiveness.

Received October 15, 2019; revised September 29, 2020; accepted January 27, 2021; electronically published March 2022.

Journal on Education in Emergencies, Vol. 8, No. 1

ISSN 2518-6833

INTRODUCTION

At least 75 million children in conflict-affected settings are currently in urgent need of education assistance, yet only 4 percent of humanitarian funding is earmarked specifically for education (Education Cannot Wait 2018). In addition to funding scarcity, substantial macro-level challenges include a lack of prioritization and coordination of education in emergencies (EiE) efforts, insufficient capacity to respond to emergencies, and a data gap concerning both what is needed and what is known to work (Nicolai et al. 2016). Child labor and marriage, repeated displacement, and rigid criteria for entry into formal education systems pose challenges for access and attendance. Moreover, teachers are frequently overburdened by having few resources and large classes of children who vary greatly in age, prior learning, and time spent out of school (Burde et al. 2017; UNESCO 2019). Thus, the need for innovative solutions to increase access to quality education is evident.

Lebanon currently hosts the highest number of refugees per capita: 1.5 million Syrians and 28,000 Palestinians from Syria, plus 180,000 Palestinian refugees who were already living in Lebanon before October 2018 (Government of Lebanon and United Nations 2019). This is in addition to 1.5 million vulnerable Lebanese, which means that vulnerable groups constitute more than half the country's population. Persistently high rates of debt, food and housing insecurity, socioeconomic disparity, substandard living conditions, exploitative work, and unmet education needs are eroding the long-term resilience of these communities. To address the impact of the rapidly increased demand on the education system, the Lebanese Ministry of Education and Higher Education opened double-shift schools and established a state-run accelerated learning program (ALP), which is the official channel for entry or reentry into the Lebanese basic education system (grades 1 to 9) (UNHCR 2016). Until recently, eligibility for entry into the ALP was based on academic competency; this represented a challenge for the many children who had experienced repeated displacement and other barriers to education access. Multilateral agencies, nongovernmental organizations (NGOs), and community-based organizations are largely responsible for implementing basic literacy and numeracy (BLN) programs in Lebanon, which aim to increase enrollment in ALP and, subsequently, formal education. BLN enrolls children ages 10-14 who either have never been to school or show no evidence of prior learning. Implementation models and content have been varied until recently, when a standardized national BLN curriculum was finalized. Despite these combined efforts, almost 1.1 million children in Lebanon remain in need of educational assistance.

Education technology (ed tech) is being explored increasingly as a means to support learning and education needs, given the limited resources and traction for a more traditional response to the aforementioned challenges. Some ed tech programs show promise; McEwan (2015) found in a systematic review that, compared to other types of school-based intervention outcomes, computer and instructional technology interventions in low- and middle-income countries had the greatest effect on learning. Furthermore, randomized controlled trials of an add-on tablet-based program in Malawi, an after-school technology-aided program in India, and a program combining e-learning with activity-based learning in Zambia have shown significant improvements in learning outcomes (Pitchford 2015; Muralidharan, Singh, and Ganimian 2016; De Hoop et al. 2020). Recently, Tauson and Stannard (2018) critically reviewed ed tech programs in humanitarian settings and, while they ultimately conclude that there is space for ed tech in humanitarian education, they recommend increased consideration of existing evidence during program design. This relates in particular to the importance of the role of the teacher or facilitator, pedagogical design, national curriculum integration, adapting to learners' levels, ensuring teacher and parent buy-in, and providing the supportive implementation infrastructure necessary for such programs to function successfully (Tauson and Stannard 2018).

Can't Wait to Learn (CWTL) is a curriculum-aligned learning program delivered on a tablet. It employs a serious gaming approach and nonspecialist facilitators to address some of the many challenges of access to quality education in conflict-affected settings. CWTL was first developed in Sudan for children living in areas where formal education infrastructure was unavailable. A quasi-experimental study indicated significantly greater learning gains in numeracy ($F(1,499)=1170.93$; $p<0.001$; $r=0.85$) among children who were offered lessons using CWTL five days per week over a period of six months than among a comparison group that received state-provided nonformal education (War Child Holland, Ahfad University for Women, and TNO 2016). The study was conducted with children ages 7-9 (N=591) who had never been to school and were living in the states of White Nile, North Kordofan, and Al Qadarif.

In the current study, War Child Holland and its partners built on these findings to further develop the program design and research tools and adapt them to the Lebanon context. While previous research focused predominantly on the game's potential to enable autonomous learning, the current proof-of-concept study explored the implementation of the program as a whole in a culturally and contextually different setting. The aim was to offer preliminary insights into the

potential impact of the program and key factors for its successful implementation in a complex, protracted refugee crisis setting.

THE GAME AND PROGRAM DESIGN

Three key learning theories underpin the development of CWTL for EiE contexts. First, according to self-determination theory, psychological wellbeing, motivation, and student retention can be enhanced through sociocontextual conditions that promote competence, autonomy, and relatedness (Ryan and Deci 2020; Fathali and Okada 2017; Eisenman 2007). In EiE, the link between education and mental health deserves specific attention. The psychosocial wellbeing of vulnerable children has been shown to predict school engagement, while the absence of education increases the risk of conflict-affected learners developing mental health disorders (Sirin and Rogers-Sirin 2015; Stiles and Gudiño 2018; Charles and Denman 2013). Second, active learning that involves the learner and creates an experiential learning process is shown to boost student engagement (Freeman et al. 2014; Sitzmann 2011; Saine et al. 2011). This is key for children who have been exposed to trauma and ongoing adversity, which has been shown to have negative effects on attention, memory, and other cognitive functions necessary for learning (Munoz et al. 2018; Sirin et al. 2018; Adubasim and Ugwu 2019). Third, Vygotsky (1978) and Csikszentmihalyi (1990) argue that learning is achieved through a balanced degree of challenge that fits within a learner's zone of proximal development. This requires a degree of individualized content, given the range of prior learning experiences among those who have experienced frequent conflict-related disruption of their education.

Features of education technology and game-based learning have the potential to operationalize aspects of the theories outlined above in EiE contexts. This includes overcoming commonplace challenges, such as a limited number of qualified teachers, high teacher-to-learner ratios, and variations in learners' ages and prior education. For instance, content that adapts to competency levels can enable learners to build momentum by staying within their zone of proximal development, which can result in deep concentration, immersion, and enjoyment, known as "flow" (Csikszentmihalyi 1990). Technology-assisted educational games can include direct feedback on performance, which teachers in overcrowded classrooms may find challenging to provide to individual students. Autonomy can be promoted by offering choices in a game, such as the option to request support, which also contributes to an active learning experience (Björk and Holopainen 2004). Varied gameplay—that is, games with different designs and goals—is

another feature that supports active learning (Björk and Holopainen 2004). This can also promote deeper conceptual understanding than a simple presentation of content and rote learning are able to (Praet and Desoete 2014; Passey et al. 2016; Clements and Sarama 2007; Kalloo, Mohan, and Kinshuk 2015; Gee 2003).

In line with these key principles for promoting both learning progress and psychosocial wellbeing, CWTL game design is based on a learner-centered sociocultural approach. This is achieved by engaging with meaningful, competency-appropriate, and contextually relevant content. To promote relatedness, the game world and its characters (see Figure 1) were co-created with out-of-school children in Lebanon, which resulted in an experiential learning interface that reflects children's realities and dreams. Interaction with these characters and instructional videos that are narrated by children are designed to increase the contextual relevance of the game, to engage emotional and cognitive processes, and to help children grasp the learning objectives (Sarama and Clements 2002; Sitzmann 2011).

Active learning through the game is promoted at two distinct game "levels" that operate like a "games within games" design pattern (Björk and Holopainen 2004). The first level is a game world that provides the connecting narratives for the second level, which consists of a variety of numeracy minigames. In the game world, children can choose to (1) explore, (2) listen to different characters' stories, and (3) help characters, which creates an autonomous and experiential learning process. For instance, the learner can help a character by completing a minigame—that is, a character can ask for help with something, then the learner plays minigames that earn points and resolve the character's issue (i.e., the learner advances through the character's story). As children successfully complete the various minigames, they progress to more difficult concepts and activities. Direct feedback and rewards are incorporated into the minigames to increase the children's sense of value in completing them. The CWTL game actively engages learners by giving them control in the first level of the game and requiring them to interact with mathematics problems in the second.

Figure 1: The Lebanon Can't Wait to Learn Game World and Two Game Characters

To ensure appropriate proximal zones of development, competency, and autonomy, three additional features are included in the CWTL program. First, children complete a placement test on first use of the game. This is an important feature for children whose education has been disrupted, as it ensures that they begin the game at a competency-appropriate level, thereby facilitating learning and increasing their motivation to engage (Tauson and Stannard 2018; Muralidharan et al. 2016). Second, scaffolded support is provided in the game through instructional videos featuring local children and adults, and an in-game guide. Third, although EiE programs are recommended to supplement rather than substitute for teachers (Tauson and Stannard 2018), the game design aims to compensate partially for the lack of qualified teachers by utilizing trained nonprofessional facilitators. The facilitators' role includes behavior, classroom, and tablet management, and encouraging use of the "steps to independence." These four steps promote independent learning when a child faces difficulty: (1) the child watches the instructional video again, (2) the child asks a friend for help, (3) the facilitator tries to elicit understanding, and (4) the facilitator explains the concept or task.

Aims of the Current Study

In this study, we aimed to determine the feasibility of delivering an education program in a conflict-affected setting. Specifically, through a mixed methods analysis involving educational and psychosocial assessments, implementation data, and qualitative user and stakeholder feedback, we examined the following:

1. Is such a program feasible to implement in Lebanon with out-of-school children?

2. Is the program associated with children's learning and psychosocial wellbeing outcomes?

3. Are there factors that may predict program dropout, enable and/or hinder successful implementation, and inform future improvements to the program?

METHODS

Setting and Study Design

We conducted a mixed methods, noncontrolled proof-of-concept study of the CWTL program for out-of-school children in Lebanon, which was implemented as a nonformal BLN education program. The design was practice driven, meaning that the research was intentionally conducted around planned program implementation and adaptations in order to gain rich quantitative and qualitative data on its feasibility and naturalistic implementation experiences and outcomes. Between September 2017 and February 2018, 30 classes from 23 centers run by 13 implementing organizations (partners) were recruited from 7 governorates of Lebanon: Akkar, North, Beqaa, Baalbek-Hermel, Mount Lebanon, South, and Nabatieh. Inclusion criteria for the partners included having the capacity to

1. conduct outreach activities and ensure attendance;

2. document the program implementation;

3. train facilitators;

4. ensure safe storage of tablets;

5. comply with War Child Holland's child safeguarding policies;

6. allow research activities and session observations; and

7. support scale-up.

CWTL was implemented for one BLN cycle, the length and start date of which varied by partner and center (mean=12.3 weeks, range=7-17 weeks), due to the unstandardized nature of BLN design and implementation at that time. A rolling baseline and endline were used to accommodate the classes' differing implementation timelines.

Participants and Sampling

We selected centers and classes nonrandomly and intentionally sought to include a range of regions and partners. Where multiple classes were conducted within one center during the implementation period, we selected one, two, or three classes for the research. We invited all eligible children in each class to take part in the research. Children were eligible if they were 10-14 years old and not currently enrolled in ALP or formal education. Children were ineligible if they displayed behavior that risked the safety of self, others, or learning materials; had hearing, speech, or vision impairment(s) that significantly limited their ability to listen to or view the game or to participate in assessments; or were unable to understand explanations in the game and learning sessions, as determined on a case-by-case basis by the research team. The quantitative sample (N=390; see Table 1 for demographic characteristics) consisted of 30 classes (mean size=13.9 children; range=2-23 children).

Table 1: Child, Parent, and Household Demographics

	Baseline sample		**Girls**		**Boys**	
	n	%	n	%	n	%
N total	390	100	184	47	206	53
Missing demographics (except region and gender)	2	0.5	1	0.5	1	0.5
Mean age (years)	11.6	--	11.5	--	11.6	--
Nationality						
Syrian	352	90.7	166	90.7	186	90.7
Lebanese	30	7.7	14	7.7	16	7.8
Palestinian Syrian	3	0.8	2	1.1	1	0.5
Palestinian Lebanese	2	0.5	1	0.5	1	0.5
Other	1	0.3	0	0.0	1	0.5
Highest grade completed						
No schooling completed	51	13.1	29	15.8	22	10.7
Grade 1	97	25.0	44	24.0	53	25.9
Grade 2	88	22.7	42	23.0	46	22.4
Grade 3	38	9.8	13	7.1	25	12.2
Grade 4	43	11.1	24	13.1	19	9.3

	Baseline sample		Girls		Boys	
	n	%	n	%	n	%
Grade 5	23	5.9	8	4.4	15	7.3
Grade 6 or above	9	2.3	5	2.7	4	2.0
Unknown or refused to answer	39	10.1	18	9.8	21	10.2
Child engaged in work[1]						
No	352	90.7	175	95.6	177	86.3
Yes	36	9.3	8	4.4	28	13.7
Child engaged in child care						
No	158	40.7	56	30.6	102	49.8
Yes	230	59.3	127	69.4	103	50.2
Housing type						
Camp	122	31.4	55	30.1	67	32.7
Rented house	104	26.8	53	29.0	51	24.9
Informal tented settlement	68	17.5	27	14.8	41	20.0
Rented room	62	16.0	33	18.0	29	14.1
Owned property	23	5.9	12	6.6	11	5.4
Living with family or friends	4	1.0	1	0.5	3	1.5
Living with host family	2	0.5	2	1.1	0	0.0
Other	3	0.8	0	0.0	3	1.5
Monthly household income (US$)						
<$299	260	67.0	112	61.2	148	72.2
$300-$599	95	24.5	49	26.8	46	22.4
$600-$899	19	4.9	15	8.2	4	2.0
$900-$1999	1	0.3	1	0.5	0	0.0
>$2000	1	0.3	0	0.0	1	0.5
Unknown or refused to answer	12	3.1	6	3.3	6	2.9

	Mothers		Fathers	
	n	%	n	%
N total	377	100.0	309	100.0
Missing demographics	13	3.4	81	26.2
Parent education				
No schooling completed	156	41.4	71	23.0
Primary school (grades 1-5) [2]	101	26.8	81	26.2
Middle school (grades 6-9) [2]	112	29.7	132	42.7
High school (grades 10-12) [2]	6	1.6	15	4.9
Tertiary education [3]	1	0.3	9	2.9
Other	1	0.3	1	0.3
Parent employment				
Homemaker	260	69.0	7	2.3
Employed for wages [4]	43	11.4	80	25.9
Self-employed	10	2.7	59	19.1

	Mothers		Fathers	
	n	%	n	%
Out of work [5]	29	7.7	97	31.4
Retired	3	0.8	1	0.3
Studying	2	0.5	0	0.0
Unable to work	13	3.4	47	15.2
Other	17	4.5	18	5.8

1 Anecdotal reports from implementing staff suggest that the actual number of children working is higher than reported by parents.
2 Completed some or all
3 Completed technical institute, some college credit, or a bachelor's degree
4 Full-time or part-time
5 Currently looking or not looking for work

Focus group discussions (FGDs; n=16) were conducted with children who participated in or completed a cycle of CWTL, their caregivers, and the program facilitators (see Table 2 for details on the qualitative sample). FGDs included between three and nine participants, and the discussions lasted 30 to 60 minutes. Due to the potentially sensitive nature of the content discussed, key informant interviews (KIIs; n=10) were conducted with children who dropped out of the program (defined as not attending any sessions three weeks or more before endline). KIIs (n=9) were also conducted with key partner staff members (see Table 2 for details). The participants were purposefully sampled by the facilitators and field supervisors to ensure a representative and mixed sample by gender, academic achievement, age, and perceived experience with the program. To account for differences between geographic locations, FGDs and KIIs were conducted across all implementation regions in Lebanon.

Table 2: Qualitative Sample Description

Type	n	Gender	Group size mean (range)	Governorates
FGDs				
Children	5	4 mixed; 1 all-female	6.6 (5-9)	A; N; B; ML; S
Parents	6	4 mixed; 2 all-female	5.7 (4-9)	A (n=2); N; B; ML; S
Facilitators	5	2 mixed; 3 all-female	4.3 (3-6)	A; N; B; ML; S
KIIs				
Program noncompleters [1]	10	4 girls, 6 boys	--	A; N; B; ML; S
Partner staff [2]	9	3 women, 6 men	--	A; N; B; BH; ML; S

Note: FGDs=focus group discussions; KIIs=key informant interviews; A=Akkar; N=North; B=Beqaa; ML=Mount Lebanon; S=South; BH=Baalbek-Hermel
1 Defined as those who did not attend for three weeks or more before endline
2 Roles included center directors (n=2), education coordinators (n=2), center coordinators (n=3), and CWTL focal points (n=2).

Facilitator Selection and Training

The partners led the facilitator recruitment, so inclusion criteria for the role varied, but a cross-cutting prerequisite was previous experience working with children. Lebanese education specialists trained the facilitators on the delivery of CWTL, including basic tablet maintenance, behavior and classroom management, and how to foster a positive learning environment conducive to independent learning. The facilitators were trained to familiarize their class with the "steps to independence" and to encourage children to follow these steps when they did not understand a concept or task. We collected demographic and psychosocial wellbeing data from 21 facilitators who were mainly female (67%), under 30 years old (52%), and a mix of nationalities, including Lebanese (62%), Syrian (24%), Palestinians already based in Lebanon (10%), and Palestinians from Syria (5%).

Procedures

Prior to the start of a BLN cycle at the participating centers, caregivers were invited to a CWTL information session led by the field supervisors, who obtained informed consent and collected demographics. Children were asked to provide their informed assent and subsequently invited to have baseline assessments taken. The facilitators' demographics and baseline wellbeing data were collected at the same time.

We intended to start the CWTL program within three weeks of the baseline assessments, but in practice this varied. The average time between baseline and program start was three weeks. During the implementation, the center and War Child Holland field supervisors maintained close contact. It was planned that War Child Holland and the partner education specialists would conduct monthly observations of each class. The partners communicated with the War Child research team when their BLN cycle was coming to an end, and endline data collection was conducted with children and facilitators shortly before or after the end of the cycle.

The facilitators notified field supervisors when a child failed to attend the program for three weeks or more. Such children were later invited to participate in KIIs. Candidates for FGDs were approached during endline data collection and invited to participate, as were partner staff members. Informed consent and assent for participation in FGDs and KIIs was obtained. Each FGD was facilitated by a trained interviewer and a note-taker, and one interviewer conducted the KIIs. All interviews were audio-recorded.

All assessments were conducted in one-to-one interviews with trained research assistants, who read scripted questions and recorded responses using Kobo Toolbox. The trainings included a six-day quantitative training and a four-day qualitative training, and a refresher training prior to endline.

Outcome and Fidelity Measures

Primary Outcome

Our primary outcome was numeracy competency, which was measured by a numeracy test designed and reviewed by education and academic test development experts. The numeracy scores and change in scores in this evaluation were both normally distributed, and a validation study of the test is ongoing. The test assessed mastery-level competency at the grade 1-3 levels in number recognition, quantity discrimination, number and place value, addition and subtraction, multiplication and division, and time and shape. The total possible score was 202 points. Skip rules were implemented so that, if a child scored less than 10 percent on a topic at one grade level, they would not progress to a higher grade level on that topic. To prevent testing effects, two versions of the test were developed and counterbalanced between students at baseline and endline. A children's booklet that contained the questions was used as an aid.

Secondary Outcomes

Secondary outcomes were the scores on psychosocial wellbeing measures. We followed a cultural adaptation process that involved piloting the measures with children to adjust the language and content as necessary to increase understanding and relevance (Van Ommeren et al. 1999).

To measure children's emotional and psychological wellbeing, we used the Stirling Children's Wellbeing Scale, a positively worded, 12-item self-report measure that employs a 5-point Likert scale (Liddle and Carter 2015). It has good internal reliability (α=0.82-0.85), good test-retest reliability (r=0.75), and good concurrent validity with measures of self-esteem (r=0.69) and wellbeing (r=0.74) (Liddle and Carter 2015). We measured children's emotional and behavioral problems with the 35-item Pediatric Symptom Checklist, using a 3-point Likert scale (Jellinek et al. 1988).

To measure children's self-esteem, we used the Moray Self-Esteem Scale, a ten-item self-report measure with a four-point Likert scale. The self-esteem scale is the Moray Council's adaptation of the Rosenburg Self-Esteem Scale, which is intended to be used with children starting at age seven. Validation and reliability data on the Moray version are not available; however, the Rosenburg version is widely used and demonstrates good internal reliability (the average from 52 countries was α=0.81; in Lebanon it was α=0.82), cross-cultural applicability, and test-retest reliability in English at two weeks (r=0.85) (Schmitt and Allik 2005; Silber and Tippett 1965).

We used the Kessler Psychological Distress Scale (K10) and the Warwick-Edinburgh Mental Wellbeing Scale to measure facilitators' levels of distress and wellbeing. The K10 is a 10-item self-report measure of distress with a 5-point Likert scale that is used in over 30 countries. In Arabic, it has shown strong internal reliability (α=0.88) (Easton et al. 2017). The Warwick-Edinburgh scale is a 14-item self-report scale of mental wellbeing that uses a 5-point Likert scale; it has demonstrated good internal consistency (α=0.72) in Lebanon (Tennant et al. 2007; Miller et al. 2020).

Process Data

The CWTL game generates log data; whenever an activity occurs, such as a video being watched or a minigame opened, data are stored in a log file. These data include the minigame level and outcome (i.e., successful or unsuccessful), date and time, and event duration. We aggregated these data to form variables of interest: the number of minigames played, total gameplay time, number of days played, and ranks in class by level in the game and rate of learning. The rank by level was computed by counting the total number of distinct game levels reached in a class, then assigning the children with the highest level as "1," the second highest as "2," and so on. Rank by rate of learning was computed in the same way, except that rank was determined by the students' rate of progression in a certain class, calculated as end level minus start level.

Qualitative Data

Topic guides for the KIIs and FGDs were developed in English, translated into Modern Standard Arabic, and then into colloquial Arabic. All FGD topic guides followed a similar format and included questions on prior experience with technology; positive and negative experiences with CWTL; the degree of ease or difficulty in participating; use and understanding of CWTL; CWTL's

perceived impact on learning, psychological wellbeing, and social relationships; and suggested improvements. The KII topic guide for program noncompleters additionally included their reasons for discontinuing the program. The KII topic guide for partner staff members covered their experience of the program, opinions on its effectiveness and the community's perception, reflections on the format and delivery mode, hypothesized barriers and facilitating factors for scaling, and suggested improvements. The interviews were audio-recorded and transcribed verbatim, then translated into English by certified translators. All transcripts and translations were checked for quality and accuracy by a bilingual member of the research team.

Implementation Fidelity

We designed a CWTL session observation form to assess the fidelity of implementation. It included items on class composition, timing, session components, and children's and facilitators' behavior. A fidelity score was calculated by summing the total score of three items:

1. The number of tablets (one point was awarded if there was one tablet per child)

2. The timing (one point was awarded if between 25 and 45 minutes were spent on the tablets)

3. Implementation of the steps to independence (one point was awarded if the steps were followed)

The observations were conducted by War Child Holland and its partner education specialists. Interrater reliability among the three observers was 79.1 percent, based on two pairs of observations.

Analysis

Statistical Analyses

We conducted the primary analysis to determine the change in numeracy competency following one BLN cycle of CWTL. A linear mixed-effect model was fitted on the intent-to-treat (ITT) sample (N=390), with a continuous score on the numeracy assessment as the dependent variable and time (pre- and post-CWTL) as the predictor variable. While ITT usually refers to a randomized

controlled trial, we define our ITT sample as including the data of all children who enrolled and completed baseline assessments, regardless of whether they completed the program or the endline assessments. Missing data were handled using restricted maximum likelihood. Corrections for clusters (random intercept) were added at the child level and the class level. We included covariates of age, gender, highest grade completed, whether the child provided child care for their siblings, mothers' and fathers' education levels, household income, and the year of arrival in Lebanon. Type II Wald Chi-square tests and bootstrapped confidence intervals were used to determine significance. Values of $p<0.05$ were interpreted as statistically significant. To quantify the magnitude of change, we calculated Cohen's *d* for each outcome by dividing the mean difference in raw scores (baseline to endline) by the baseline standard deviation. Note that these effect size estimates do not take into account the random variance estimated by the model, and therefore must be interpreted with caution.

We conducted secondary analyses to analyze changes in children's wellbeing using ITT and three linear mixed-effect models, with continuous scores in psychosocial wellbeing outcomes (wellbeing, self-esteem, and psychological symptoms) as dependent variables. Cluster corrections and covariates were as per above. We repeated the primary and secondary analyses using a per-protocol sample, defined as children who completed both baseline and endline and attended more than 40 percent of the CWTL sessions available to them (n=196). However, since these analyses did not change our interpretation of the results, only the ITT results are reported here.

Exploratory Analyses

We also carried out a series of exploratory analyses. However, the statistical power for these analyses was low, so their function was to generate rather than confirm hypotheses.

Facilitator wellbeing: We conducted Wilcoxon signed-rank tests on the K10 and Warwick-Edinburgh scale scores to assess pre/post change in facilitator distress and wellbeing over time.

Predictors of dropout: We used logistic regression to identify predictors of dropout and included the following variables in the model: class, gender, age, whether the child worked or cared for siblings, household income, last school grade completed (if any), mothers' and fathers' education level, mothers' and fathers'

employment status, whether the father lived in the home, rank by level, and baseline psychological outcomes (wellbeing, psychological symptoms, self-esteem).

Predictors of poor attendance: We defined a minimally adequate rate of attendance for the CWTL program as 40 percent over the cycle. This was a consensus decision by the CWTL program director and the Lebanon program manager, who took the common attendance rates in the BLN programs in this context into consideration. We used bias-reducing Firth logistic regression analyses (Firth 1993) to explore whether demographic, baseline (numeracy competency and psychosocial wellbeing), or implementation variables predict less than minimally adequate attendance. We tested the same variables as in the dropout analysis.

Qualitative Analysis

Three authors carried out a framework analysis—a combination of content analysis with a data visualization tool—on the KII and FGD transcripts (Gale et al. 2013).[1] Interrater reliability among the three coders was κ=0.82, which was deemed "strong" (McHugh 2012). Following a mixed methods approach, we compared qualitative and quantitative data from the children and facilitators and qualitative data from other stakeholders, with the aim of gaining a rich understanding of the experience, process, and outcomes of the program.

ETHICS

Ethical approval was obtained from the Institutional Review Board of the American Institutes for Research. We protected participant confidentiality by using participant codes instead of names. We trained the research assistants, facilitators, and key partner staff members to recognize and report concerns about child protection and adverse events. The core research team discussed these reports on a monthly basis and agreed on appropriate action, where necessary.

RESULTS

A total of 390 children (47% female) were enrolled in the study at baseline, 82 of whom (21%) did not complete the program (defined as not attending for at least 21 consecutive days prior to endline); 82 children (21%) did not attend a single

1 These three authors are Jasmine S. Turner, Nisreen Ibrahim, and Eyad Hallak.

session. At endline, 286 children (49% female) remained in the study, indicating an attrition rate of 27 percent (n=104; see Figure 2). No major adverse events were reported. We grouped our findings into four subsections, which include our quantitative findings and nine qualitative themes (see Figure 3).

Figure 2: Participant Flow Chart

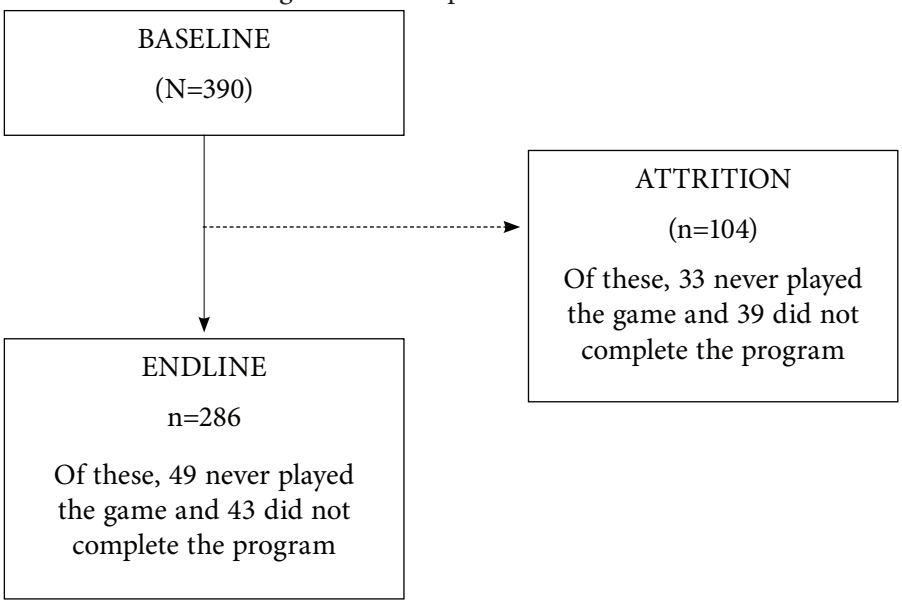
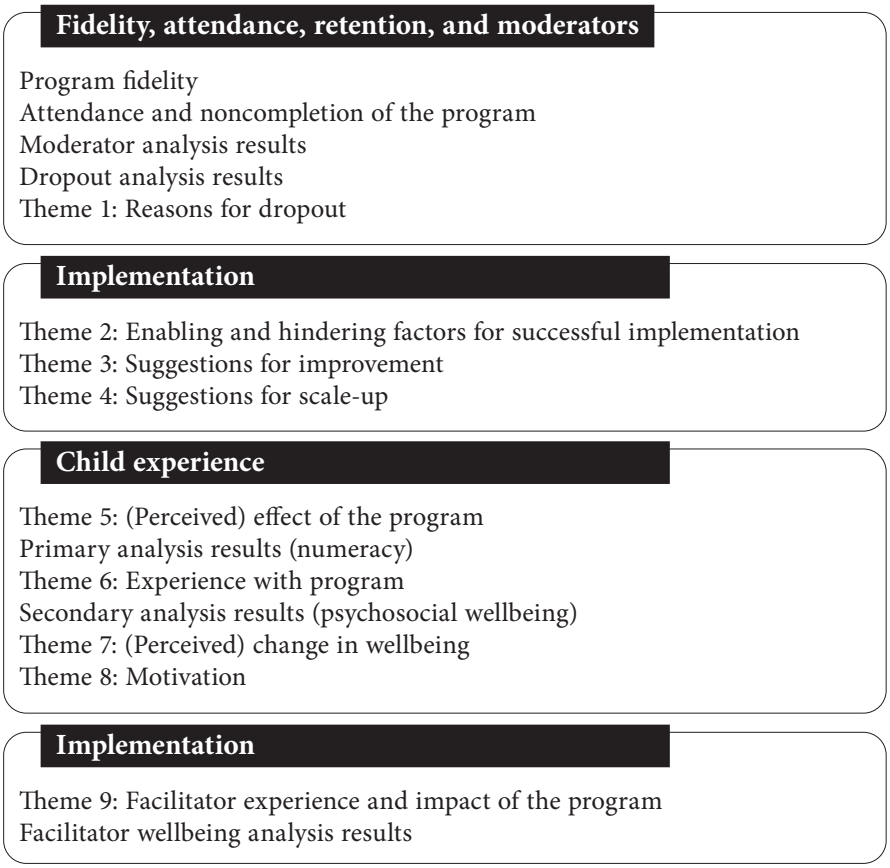


Figure 3: Categorization of Mixed Methods Results



Fidelity, Attendance, and Retention

Only 60 percent of the children completed the program; 20 percent started but did not complete it, and 20 percent enrolled but did not attend a single session. Average attendance was relatively low in absolute terms (M=46%, equivalent to two days per week). Rank by level, which ranked children in each class according to the level they were at in the game, was significantly associated (p<0.05) with attendance, such that, with each lower rank, a child was 1.72 times more likely to have less than minimally adequate attendance, or lower than 40 percent. However, it is important to note that the causality of this relationship is unknown.

A total of 104 children who completed baseline did not complete the endline assessment (27% of baseline sample). The reason for dropout most often cited was leaving the area (n=35), with at least a quarter of these families specifying that they were returning to Syria. Children in two specific classes—between September 2017

and February 2018, 30 classes from 23 centers run by 13 implementing organizations were recruited—had higher odds of dropping out (odds ratio [*OR*]=21.62, $p<0.01$; *OR*=10.50, $p<0.05$); however, 75 percent of the combined dropouts for these classes was reportedly because children's families moved away. Twelve children (12%) dropped out because they enrolled in formal education—a positive finding—which they also referred to in the FGDs and KIIs (Theme 1). The logistic regression analyses indicated that children who worked—13 percent of those who dropped out—were more than twice as likely to drop out of the CWTL program than those who did not work (*OR*=2.17, $p<0.05$). Dropout due to child labor was also cited frequently in the qualitative data by all participant types and across all regions. One center coordinator described child labor as "the most difficult thing we face." One child who dropped out explained that his decision to stop the program in order to work was voluntary: "It's not that my parents forced me to . . . I want to help my parents." Of those who dropped out due to work, 62 percent were male.

Other reasons reported for dropout included children's illness (6%), a child's withdrawn assent (4%), family obligations (2%), and permission withdrawn by husband/fiancé (2%) or father (1%). In line with the last two reasons, one girl described how she had been pressured to stop attending CWTL by older men in the community because she was "too old" for education (Theme 1). The reason for dropout was unknown for 28 percent of the cases. Additional reasons given in the FGDs and KIIs included dissatisfaction with the repetition in the minigames and the amount of time spent fixing problems with the tablets, challenges getting to the center, issues with classmates, and a desire for incentives to participate. Although gender was not found to be significantly associated with dropout, it is important to recognize that gender is intrinsically linked to some of the reasons for dropout reported above.

Monthly session observations were planned for each class; however, this was not achieved, due to the prioritization of outreach, data collection, and partner support. The mean fidelity score was 2.43 out of 3 (equivalent to 81%; *SD*=0.8; see Table 3 below for the breakdown of scores per item) based on 44 observations (approximately 2.4% of sessions) of 22 facilitators in 20 centers (range=1-7 observations per facilitator). In all but one of the sessions observed, children spent the correct amount of time on the tablets; however, there were not enough tablets for all the children in a quarter of the sessions observed. In two-thirds of the sessions, the steps to independence were implemented correctly. In many of the sessions where the steps to independence were not followed, comments in the observation form indicated that facilitators frequently stepped in too early to help the children.

Table 3: Scores on Fidelity Items

Fidelity	Yes	No
Enough tablets	33 (75%)	11 (25%)
Adequate time on tablets	43 (98%)	1 (2%)
Implementation of steps to independence[1]	29 (66%)	13 (30%)

1 Two observations had missing data and were excluded.

Implementation

The FGD and KII participants discussed what they perceived to be enabling and hindering factors for successful implementation, recommendations for program improvement, and ideas for scale-up. Following some initial hesitation about using technology in education, CWTL was embraced because it was felt to be "in line with the era of development and technology" (center director) and to support the rights of refugee students to "be like everyone else" (center coordinator) by exposing them to technology (Theme 2). Many facilitators and partner staff members felt that use of the game should complement facilitator-led teaching: "If you want it to succeed, let it be in parallel with papers and pens" (education coordinator; Themes 3 and 9). Parents often demonstrated limited familiarity with the program and a lack of understanding of its methods, but also expressed a desire to change this and to be able to support their children's learning in the home more effectively (Theme 2). Integrating the program into the Lebanese formal education system was the most frequent suggestion for scale-up, along with more promotion of and communication about CWTL, and about the importance of education to boost awareness, buy-in, and uptake of the CWTL program by parents, communities, and other NGOs (Theme 4).

The partner staff members and facilitators commented favorably on the partnership with War Child Holland with respect to information technology and facilitator trainings, regular communication, and the "very responsive" field supervisors (education coordinator; Theme 2). Partner staff members advocated for continued scale-up through partnerships with international and local NGOs (Theme 4). The main recommendations and requests for improving the partnership were reduced tablet maintenance time, more exposure to the game for facilitators and partner staff members prior to the program rollout, improved coordination of outreach and rollout, and the provision of incentives to increase enrollment and retention (Theme 3).

The centers were generally perceived as very accessible, which was facilitated by the provision of transportation by War Child Holland and the partners (Theme 2). The classroom environment was positively described as "calm" (child) and somewhere where a child can "find a wider learning" (father; Theme 2). However, as mentioned previously, the facilitators indicated that they would find increased instruction in classroom and behavior management beneficial (Themes 9 and 3). Suggestions on how to improve the program further included separating the class by age and/or ability and extending access to the program to younger children (Theme 3).

Additional suggested improvements to the game, program design, and implementation included having more succinct and enthusiastic instructional videos, less-repetitive minigames, an extended range of minigame levels (both easier and harder levels were requested), and data-driven progress reports to facilitate individualized support (Theme 3). Suggestions were made to both lengthen and shorten the duration of the sessions, and requests were voiced for additional games to teach Arabic, French, English, science, and the humanities (Theme 3).

Child Experience

Children, facilitators, caregivers, and partner staff members perceived improvements in numeracy competency: "It benefitted me with a lot of things. I now have a better understanding in addition and subtraction and such things, and now, any question, I can know right away" (child; Theme 5). Participants also attributed other improvements to the program, including comprehension and usage of Modern Standard Arabic, technological literacy, and skills key to learning, such as attention, concentration, problem-solving, self-discipline, and perseverance (Theme 5). The quantitative results supported this and indicated a significant increase in numeracy competency between baseline and endline ($\chi^2(1)=125.77$, $p<0.001$, $d=0.3$; see Figure 3 and Table 4 for details). Two covariates were significant, including gender ($\chi^2(1)=4.06$, $p<0.05$), with boys scoring higher overall (average mean difference=12.61), and age ($\chi^2(1)=13.36$, $p<0.001$), with a linear increase in mean score with increasing age.

Figure 4: Mean Numeracy Score Pre- and Post-CWTL

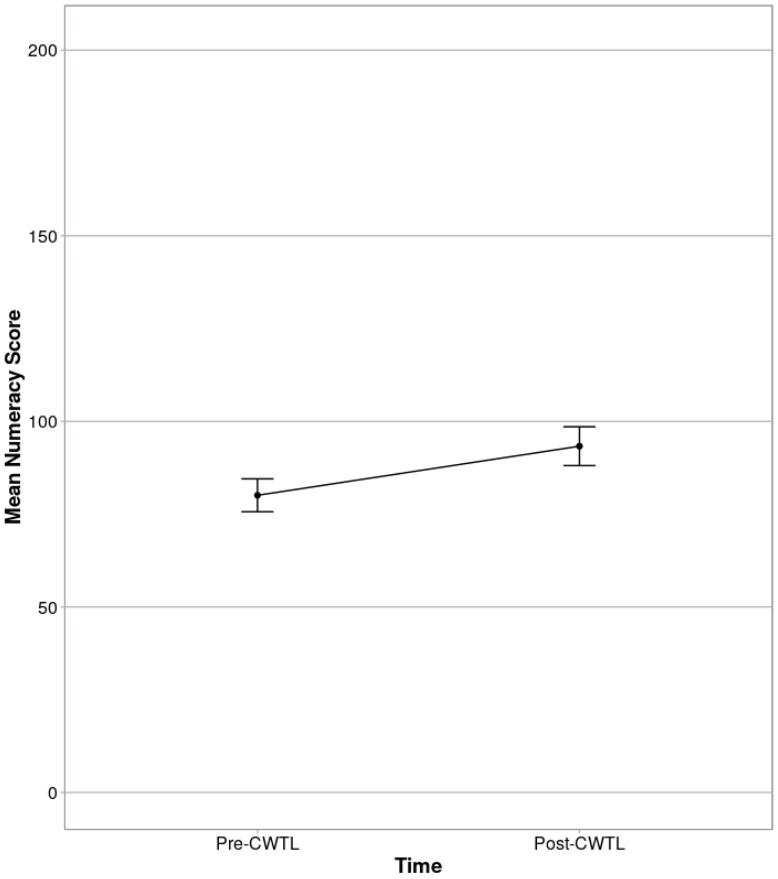


Table 4: Intention-to-Treat Results for Numeracy and Psychosocial Wellbeing Outcomes

Measure	Pre-CWTL		Pre-CWTL		χ^2	Coefficient
	M	SD	M	SD		
Numeracy [1]	80.08	44.28	93.3[1]	44.96	125.77***	-7.31
Moray Self-Esteem Scale	3.03[2]	0.43	3.16[2]	0.42	6.34*	-0.05
Pediatric Symptoms Checklist	0.64[2]	0.25	0.59[2]	0.26	8.87**	-0.03
Stirling Wellbeing Scale	3.81[2]	0.62	3.90[2]	0.68	0.89	-0.02

1 Out of a maximum 202 points
2 Item mean
* $p<0.05$, ** $p<0.01$, *** $p<0.001$; means are unadjusted for clustering or covariates

In terms of experience with the program, children commented favorably on the game, facilitators, and tablets (Theme 6). The children particularly liked the autonomy the game afforded, in terms of choosing characters within the game and being able to listen to instructions when they wanted. Over time, however, playing the same minigames repeatedly became boring and tablet malfunction was frustrating. Increased motivation to learn emerged as a strong theme and was attributed mainly to the tablets and the desire to discover the game world. One facilitator explained that "[the children] wanted to see the end of the game. They wanted to reach a goal" (Theme 8).

The facilitators hypothesized that a perceived increase in self-esteem was linked to the independent approach to learning: "[The children] start to have confidence in knowing that they found it and solved it on their own. 'I found out . . . without anybody's help. I found it on my own.' There's a lot of . . . confidence. There's also more self-reliance" (facilitator; Theme 7). This was corroborated by a statistically significant increase in self-esteem ($\chi^2(1)=6.34$, $p<0.05$, $d=0.3$). Children were observed to have become "more at ease" (parent) and "relaxed psychologically" (facilitator) after starting CWTL, and the results indicated a significant decrease in psychological symptoms ($\chi^2(1)=8.87$, $p<0.01$, $d=0.2$). There was no significant change in wellbeing scores over time. We analyzed the psychometric properties of these measures using confirmatory factor analyses and calculating omega3 (ω_3) as a measure of internal consistency. We found a good fit for a one-factor model (indicating unidimensionality) for each measure, and we found acceptable internal consistency for wellbeing ($\omega_3=0.84$) and psychological symptoms ($\omega_3=0.87$). However, the self-esteem measure had less than acceptable internal consistency ($\omega_3=0.69$); therefore, findings related to self-esteem should be interpreted with caution in this sample of children

The majority of participants noted strengthened social bonds and collaboration among the children, the development of friendships, and healthy competition using the minigames (Theme 7). As one facilitator reflected, "I felt that my students who had something aggressive in their personalities changed after two weeks of their being in the center. They started to talk in the whole break about what they did in the game. I heard one of them telling the other, 'When you reach this level, I will help you. Don't be afraid! If you are making any mistake, I can help you, as I understand it well.'" However, overall qualitative evidence on the perceived social effects of the program was mixed, with some participants commenting that teasing and bullying occurred in some classes and that the celebrated achievements of some made those at lower levels in the game sometimes

feel inferior. These challenges could have contributed to the mixed quantitative findings on wellbeing outcomes.

Facilitator Experience

A key finding from the qualitative analysis was that, on the whole, the facilitators were well liked and they fostered positive, warm relationships with the children that led, ultimately, to increased enjoyment of the program by both the children and the facilitators. Another finding was that, while the facilitators found the tablet management relatively straightforward, many expressed a lack of clarity about their role versus the role of the tablet in the context of an ed tech program. The facilitators wanted a more active teaching role and felt that they would benefit from additional training on behavior management. This lack of clarity and frustration linked to feeling like passive observers could have contributed to the lack of significant change in mental wellbeing measured over time, although this could also be due to a lack of power or other unmeasured factors.

In the FGDs, facilitators reported that the program had a positive impact on them (Theme 9). Several described an increase in their empathy and understanding of the contexts and experiences of the children they worked with; as one facilitator said, "You learn a lot . . . I learned from them maybe more than they did from me." Furthermore, facilitators commented that their participation in CWTL had taught them "patience" and to be "relaxed" and "calm," which is in line with the significant reduction in distress scores (n=20; K10 mean difference=-2.75, r=0.377, p<0.05). Conversely, we saw no significant quantitative change in facilitator wellbeing.

DISCUSSION

The results of our mixed methods evaluation support the feasibility of using a digital game-based program, Can't Wait to Learn, for out-of-school children in a conflict-affected country. Our increased understanding of the children's lived experience of the program and desired improvements will enable the team to address challenges associated with attendance, retention, and successful implementation. This will increase the ability of CWTL to help close the education gap in Lebanon. Despite low attendance levels, we found statistically significant increases over time in children's numeracy competency and self-esteem, and a statistically significant reduction over time in children's psychological symptoms. Participants and key stakeholders, including facilitators, parents, and partner staff members, attributed

these changes to the program. Causality cannot be attributed solely to CWTL, due to the lack of a comparison group, but it is plausible that the improvements in numeracy and wellbeing are at least partially due to CWTL, as learning across such a diverse sample would not have occurred without pedagogical instruction.

Program attendance was lower than anticipated, with only 58 percent of children completing what we defined as a minimally adequate number (more than 40%) of sessions. On the one hand, we can argue that this strengthens evidence for the program's possible positive effects, in that learning outcomes significantly increased over time despite low attendance. On the other hand, there is clearly room for improvement. Fully powered analyses of predictors of attendance and dropout would support the development of additional strategies to increase attendance and retention. The qualitative and quantitative exploration of the challenges to consistent attendance and retention and of ways to overcome them to increase the potency of the program have implications for the wider education sector, as well as for CWTL specifically. As suggested by partner staff members, increased dialogue with parents and the wider community about education, including the role technology can play, could stimulate increased buy-in and address gender-specific reasons for dropout. A more flexible session format (e.g., time of day, session length, division by age or ability) could help with class and behavior management and ultimately increase learning efficiency. Finally, the many reports of families moving within Lebanon or returning to Syria reaffirm the need for the certification of nonformal education programs to facilitate and encourage children's integration into formal education systems.

Our study also supports the feasibility of using nonprofessional facilitators to overcome shortages of qualified teachers, although our findings also suggest the need for some changes to their originally envisaged role in the program; namely, it should be limited to classroom and tablet management. Key findings are the degree to which the facilitators affected children's experience of the program and the program's described effect on the facilitators. It is possible that, while it was feasible to deliver the program through nonprofessional facilitators, a more pedagogical role could further boost the children's positive experiences and psychological outcomes, and those of the facilitators themselves, without requiring substantial additional training (Islam and Grönlund 2016; Tauson and Stannard 2018). Having teacher-led scaffolding or adult support in parallel with technology has been shown to produce more sustained learning, in part due to a human's ability to differentiate between a mistake and a lack of understanding, which a computer program cannot do (Cayton-Hodges, Feng, and Pan 2015). As indicated by our data on the fidelity of implementation, in one-third of the sessions

we observed, the facilitators provided direct instruction instead of encouraging children to use the steps to independence. This additional support may have affected children's learning differentially; therefore, the program design and future studies should focus on harnessing the facilitators' potential and identifying their optimal level of involvement for the children's long-term academic progress.

In line with previous research, the significant improvement in numeracy scores (d=0.3), combined with the reported positive experiences with the program, point to the potential of a digital game-based learning program to meet the heterogenous education needs of out-of-school children (Pitchford 2015; Muralidharan et al. 2016; McEwan 2015; Tauson and Stannard 2018; Sirin et al. 2018). Consistent with self-determination theory, the reported increase in motivation and skills such as problem-solving and concentration suggests that the game may generate self-determination and intrinsic motivation to some extent, which facilitates learning (Eseryel et al. 2014). However, reports of boredom and frustration, repetition, and minigames that were too easy or too difficult suggest that the game does not yet stay within all children's zone of proximal development (Csikszentmihalyi 1990; Vygotsky 1978). To address this, and in line with recommendations from the study participants, refinements to the game design, including shorter, more enthusiastic videos, more permitted errors in a streak, and less repetition, have been made and applied to subsequent iterations of CWTL. Other improvements to the game design, such as directing children to repeat content when necessary, are currently being investigated.

The significant improvement in self-esteem and psychological symptoms and the self-reported and observed positive psychological and social effects on children suggest that participation in CWTL may have a positive influence on psychosocial outcomes. It is plausible that being engaged in and celebrating the learning of new concepts and skills, reinforced by in-game rewards upon successful completion of minigames, could have a positive effect on wellbeing, which is in line with existing evidence on the positive impact academic learning has on psychosocial wellbeing (Burde et al. 2015; Ryan and Deci 2020; Winthrop and Kirk 2008). Although current evidence on the relationship between ed tech programs and children's wellbeing is mixed, our findings support a positive relationship that merits further investigation (Dunn, Bundy, and Woodrow 2012; Spitzer 2014; Tauson and Stannard 2018).

We recognize several limitations to this study and are addressing them in subsequent studies. First, the lack of a control group precludes claims of causality; therefore, we have conducted quasi-experimental studies in Sudan and Jordan using active comparison groups (Brown et al. 2020; de Hoop et al. under review)

and a randomized controlled trial is being prepared. Second, although the scores and the change in scores of the numeracy assessment were normally distributed, further evidence of the validity of the assessment is required; therefore, we are currently undertaking a validation study. The assessment was developed to cover the Lebanese curriculum and to be more sensitive to change than existing measures, but this limits the comparability of CWTL to other education programs. Third, although it was originally intended as a primary outcome, data on the transition to state-run accelerated and formal education programs were not systematically collected. This was due to a change to, and lack of clarity on, the eligibility criteria shortly after the study began. Fourth, the use of Modern Standard Arabic in the numeracy assessments may have had implications for the children's comprehension, especially for those with little or no prior schooling. However, it was necessary to ensure the reliability of the data, as the Arabic dialects spoken by the children varied. Finally, although an attrition analysis showed no systematic reasons for dropout, we cannot rule out selection bias in the sample; a randomized controlled trial with random sampling will be necessary to ensure a representative sample.

In conclusion, our findings support the feasibility of using ed tech programs, such as CWTL, to meet the education needs of out-of-school children in Lebanon. We found promising measured and reported improvements in numeracy outcomes, improvements in psychosocial outcomes, and high engagement, motivation, and enjoyment of the program. These findings suggest the potential of such programs to address children's compromised access to quality education in humanitarian settings and to mitigate the negative consequences of conflict. The findings suggest that there is a place for technology in the humanitarian education response, but also that technology should be considered just one of the multiple components that comprise a successful education program. We identified key challenges in ensuring children's attendance and in enabling the facilitators to have a clear role in scaffolding learning from the game. The recommendations from this study have informed subsequent implementation of CWTL in Jordan, Sudan, Uganda, Bangladesh, and Chad, as well as more rigorous evaluations to determine its impact and the optimal implementation quality frameworks. Ongoing research aims to understand how CWTL, and ed tech programs more generally, can be adapted to different contexts and needs and can be scaled-up to increase access to and the quality of education in conflict-affected settings.

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