GraphoLearn India: The Effectiveness of a Computer-assisted Reading Intervention in Supporting English Readers in India

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Master's Thesis in Education
Spring Term 2018
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ABSTRACT

Patel, Priyanka. 2018. GraphoLearn India: the effectiveness of a computer-assisted reading intervention in supporting English readers in India. Master's Thesis in Education. University of Jyväskylä. Department of Education & Psychology.

Illiteracy is still a critical problem in many parts of the developing world. India, with a population of over 1.3 billion individuals, has a literacy rate of only 72%. Those living in poverty are at an even higher risk of never achieving literacy due to limited access to quality education. With a strong push towards English education sweeping the country, those in poverty further struggle to learn a language which is foreign to them. Without access to quality education, these individuals are ultimately never given the chance to break the cycle of poverty.

The aim of this study was to determine whether GraphoLearn, a computer-assisted reading intervention, could be used to support the English reading skills of struggling readers in India. Participants were 7-year-old, grade 3 students (N=30), who were attending an English-medium public school in Ahmedabad, India. English was not a native language for any of the students and all were reading at a level below that of grade 1 despite having attended school for 2 years.

Half of the students played GraphoLearn (n=16) while the other half played a control math game (n=14) for 20-30 minutes a day, over a period of 8 weeks. GraphoLearn led to significant improvements in children's letter-sound knowledge, a critical factor in early reading development. Small to medium effects were also present for other tasks of reading and spelling. These results indicate that GraphoLearn has the potential to successfully support struggling readers of English in India, including those who are learning a non-native language and coming from at-risk backgrounds.

Keywords: GraphoLearn, literacy, India, phonics, technology

ACKNOWLEDGEMENTS

First and foremost, I would like to thank the Ahmedabad Municipal Corporation School Board for granting me permission to carry out this study. I would also like to thank the principal and staff of the respective schools for their flexibility and openness throughout the intervention period.

A heartfelt thanks to the 25 children I taught when I was a teacher in India and the almost 50 kids I worked with throughout the data collection process for being a constant source of positivity in what could be the toughest situations. Their limitless joy every day when I walked into the school is what kept me going then and keeps me going even now.

I would like to express my gratitude to my supervisor, Minna Torppa, for not only her endless support and guidance along this journey, but also for being a role model. Thank you to Kenneth Eklund for taking the time out to support me with my data analysis. I would also like to thank Heikki Lyytinen and Ulla Richardson for allowing me to take GraphoLearn to India and providing me with their expertise.

Thank you to my friends both near and far, for your constant encouragement and support throughout this entire process. Special mention to Augmented Understanding for supporting the data collection process.

I would like to give a special thank you to Kushal Dattani for encouraging me to experience India in its truest sense, all while standing by my side. Thank you for being that constant source of positivity and always pushing me to be and do better.

Last, but certainly not the least, I would like to thank my mom and grandparents for their unrelenting support. It's because of them that I have the courage to take the road less traveled. I love you all and I hope I can continue to make you all proud.

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1 INTRODUCTION

Despite international moves and agreements to improve literacy around the world, many developing countries are still struggling with high rates of illiteracy. India, a country with a population of 1.3 billion individuals, only has a literacy rate of 72% among those 15 years and older, leaving more than 259 million youth and adults as illiterates (UNESCO, 2015). In a country developing as quickly as India, an illiteracy rate as high as this is a large problem, putting many individuals at risk of never being able to reach opportunities and act as contributing members of society. With 17 official languages (as recognized by the United Nations) and more than 700 dialects, (Dixon, Schagen, & Seedhouse, 2011; Mitra, Tooley, Inamdar, & Dixon, 2003), and with 21%, or 269 million, people living below the poverty line (The World Bank, 2011), solving India's literacy crisis is an extremely large task.

Education plays a major role in literacy and, therefore, some believe that one strategy to start combatting the problem may be to look at countries with successful education systems and borrow interventions that can be implemented elsewhere (Ojanen et al., 2015). Children in India, especially those living in poverty, face many problems in education. Slum and other low-income children are forced to attend low quality schools, which are under-resourced and use poor teaching methods (Cheney, Ruzzi, & Muralidharan, 2005; Kingdon, 2007). With a country-wide push towards English medium education, these students are studying in a language which they may have no prior exposure to and no support at home for. Due to these factors, these children struggle to learn English and attain a quality education. In turn, many of these children will never have the option of higher education, and once again, they will find themselves stuck in the cycle of poverty. According to The World Bank, 45% of the poor are illiterate as compared to 26% of the non-poor (2012).

The purpose of this study is to determine whether GraphoLearn, a computer-assisted reading intervention originally created for struggling readers of Finnish, can be used to support struggling readers of English in India. The major focus being

on slum children attending government-aided public schools in Gujarat, India who are non-native speakers of English, and at high risk of never achieving fluent English literacy.

2 ENGLISH IN INDIA

English as a language was originally brought to India by the British who arrived in the 1600s and established trade posts through the East India company (Mehrotra, 1998). English was used throughout the British rule between traders and merchants, as well as by Christian missionaries (Mehrotra, 1998). During this time, English was viewed as a language of the elite, a view that has been upheld even post Indian independence in 1947 (Mishra & Stainthorp, 2007). In present day India, it is common for individuals to use a variety of languages in everyday life (Mishra & Stainthorp, 2007). It may even be that one language is used in the workplace or school, while another language is used in speaking to peers, and then the mother tongue is used in speaking to family and other relatives. Being that India is a highly multicultural country, English has been maintained and acts as a common bridging language across states (Mitra et al., 2003). British rule also brought with it a tradition of English medium education to India (Annamalai, 2004). This was maintained as there was no other language throughout the country which would be accepted by the linguistic minorities (Mishra & Stainthorp, 2007).

Today, English is the only language that is taught in all states and in the most number of schools across the country (Annamalai, 2004). Individuals who speak English are coveted by employers (Annamalai, 2004; Mitra et al., 2003) and it has become a very important language particularly in higher education (Annamalai, 2004; Cheney et al., 2005; Mehrotra, 1998) with the majority of high level institutions only providing English instruction. In this sense, English has the ability to influence the standard of living in India; with those having better English skills getting better job opportunities, and in turn better pay (Mehrotra, 1998; Mitra et al., 2003). As

parents realize the opportunity that comes with learning English, many are actively choosing to enroll their children in English medium schools. This is true even for parents from poor slum areas who have started believing that the ability to read, write, and speak in English will increase opportunity for their children (Dixon et al., 2011; Mehrotra, 1998; Mitra et al., 2003).

However, children growing up in slum communities are at a large disadvantage when it comes to learning the English language (Annamalai, 2004). Slum children often have no exposure to English prior to entering school, as parents typically cannot speak or communicate in English. It is also likely that these parents are illiterate in their mother tongue as well (Dixon et al., 2011), meaning that their children will have no exposure to literacy in any language prior to school entry. According to Nag (2013) children who miss such supports, such as having a print rich environment with access to reading material or an adult to read to them, tend to develop profiles which are similar to those with dyslexia or other reading difficulties. Thus, children are at high risk even before they enter school.

Parents from this level of society, typically have two choices in terms of schools for their children; government -aided public schools or low-income, unaided private schools (Cheney et al., 2005). Due to the high demand for English, there has been a "mushrooming" of low-cost private schools (Tooley & Dixon, 2005), and now English is also taught as a primary language in public government schools. In most of these public and private schools, teaching quality is low and children are forced to rote learn a language they do not fully understand (Annamalai, 2004; Dixon et al., 2011). On the contrary, there are also many private schools across the country which follow international board curriculum and provide high quality English education. However, these schools charge high fees making them completely inaccessible to the low-income population (Cheney et al., 2005).

3 ENGLISH MEDIUM EDUCATION IN INDIA

India has the second largest educational system in the world, following only behind China (Cheney et al., 2005). The country follows a British system of education in which Grades 1-5 (ages 6-11) comprise of primary schooling, and Grades 6-8 (ages 11-14) comprise of upper primary/secondary schooling (Cheney et al., 2005). According to the 86th amendment to the Constitution, which was made in 2002, education up until the age of 14 is free and compulsory for all children in India (MHRD, 2016). Typically, children who are attending school can choose between three different mediums of instruction which are Hindi, English, or the state language. Depending on the school, the other two languages are then introduced at a later time. Hindi and English are the two official languages recognized at the federal level. The other 15 languages are recognized at a state level and make up the state languages across the country (Annamalai, 2004; Dixon et al., 2011; Mitra et al., 2003).

In English medium schools, English is the primary language of instruction, meaning that all subjects are taught in English, with Hindi and the state language taught as second and/or third languages. Currently there are 90 million children across various socioeconomic statuses that are becoming literate in English (Kaila & Reese, 2009), and according to the latest Annual Status of Education Report (ASER), 95.9% of children ages 6-14 are enrolled in school across India (2016). Although school enrollment is high, learning achievements of these enrolled children are consistently low (Kingdon, 2007). Across all languages, only 47.8% of children in Grade 5 are able to read a Grade 2 level text (ASER, 2016). When looking at English, of all surveyed children in Grade 3, only 19.3% could read simple words such as "day" or "sit" (ASER, 2016). Although the ASER report only surveys children in rural India, data from the National Achievement Survey (NAS) shows that the situation in urban India is not strikingly different. The NAS primarily uses reading comprehension as a measure of language and it was found that nationwide, Grade

5 students only scored an average of 241 out of a total 500 on the reading comprehension questionnaire (NCERT, 2015).

As Dixon et al. (2011) observed through their research, currently children in India, particularly those in low-income schools, are taught English in a rote manner. They learn the names of letters and then are expected to learn "common" words through a whole-word method in which students essentially learn to recognize words through sight. Like words, sentences are also learned through rote memorization (Dixon et al., 2011). However, many researchers have criticized the whole word approach as it requires that readers memorize a large set of words and it does not give them the skill to read any unknown or unfamiliar words (Purewal, 2008). The whole word approach also requires children to already have been exposed to a large vocabulary which is unlikely when working with slum children in India due to their lack of prior exposure to the language.

4 PHONOLOGICAL AWARENESS AMONG BILINGUAL READERS

Reading is complex skill which requires explicit instruction, unlike with spoken language, which children pick up from the environment around them (Purewal, 2008; Wolf, Gottwald, Galyean, Morris, & Breazeal, 2014). According to researchers, this complexity increases when mother tongue language and the language of school instruction differ (Hammer & Miccio, 2006). Children in India are predominantly bilingual (and in some cases even multilingual), which creates a unique educational situation. Most children are exposed to their mother tongue prior to entering school, upon which they may begin to study in a language which they have no previous exposure. If the mother and father happen to speak different languages, then they may already encounter two different languages before starting formal schooling (Mishra & Stainthorp, 2007). However, research has shown that the development of English reading skills, particularly phonemic awareness, among bilingual students

is actually quite similar to the development of reading skills in native English speakers (Muter & Diethelm, 2001). Furthermore, this development has been found to be more reliant on instruction and individual differences than on factors such as fluency in English (Lesaux & Siegal 2003).

Phonemic awareness, or the ability to map phonemes, or sounds, to their respective graphemes, or letters, is a crucial factor in early reading development (Hatcher, Hulme, & Ellis, 1994). The link between phonemic awareness and early reading development in native speakers of English is one which has been established for more than two decades now (see Hatcher et al., 1994; Torgesen et al., 1999). More recently, such links have also been identified in those learning English as a second language (Chiappe & Siegel, 2006), and phonological awareness in a first language may actually predict phonological awareness in English (Durgunoglu, Nagy, & Hancin-Bhatt, 1993).

Researchers in Canada conducted one of the few studies examining children whose home language differs from the language in which they study. They compared children who were either native English speakers or native speakers of Punjabi and found that for both groups, errors in reading were due to the inability to apply grapheme-phoneme correspondences to unfamiliar words (Chiappe & Siegel, 1999) with poor readers being less skilled at this application. Another interesting finding was that phonological awareness did not discriminate based on home language, but rather based on reading skill; Punjabi children who struggled to read English had similar performance profiles as the native English speakers who were poor readers (Chiappe & Siegel, 1999). These results also support the idea that phonological awareness skills do transfer from the first to the second language (Chiappe & Siegel, 1999; Lesaux & Siegal 2003). Similar results were found for English reading with children whose first language is non-alphabetic. When comparing native English-speaking children with children whose first language was Cantonese, researchers found that phonological skills correlated across first and second languages (Lipka & Siegel, 2007). These results showed that the same factors contributed to reading development in both of these groups. Furthermore, it has

been found that even bilingual children coming from low-income backgrounds can acquire the same level of phonological awareness as their native English-speaking peers, if they get the appropriate level and type of instruction (see Hammer & Miccio, 2006).

There is growing evidence that phonological awareness also plays a role with Indian children, in India, who are learning to read English. A study conducted by Nag-Arulmani and colleagues looked at struggling readers of English who spoke Kannada, a south Indian language, as a dominant language. Participants received an intervention in either phonological skill or language proficiency. At the end of the intervention period, it was seen that the group which received the phonological skill intervention showed significant improvements in reading and spelling (Nag-Arulmani, Reddy, & Buckley, 2003). Based on these studies, we can see that phonological processing plays a role in reading acquisition for both native and non-native speakers, and is an important factor in the reading development of children growing up in various linguistic environments when learning to read in English.

5 READING THROUGH PHONICS

As mentioned previously, in low-income private and government-aided public schools in India, English is typically taught in a rote matter (Johnston & Watson, 2005). Children memorize whole words through sight and are therefore unable to decode or blend unfamiliar words (Dixon et al., 2011). Unfortunately, this whole word rote memorization is quite inefficient when learning a language like English. Many researchers agree that reading acquisition in English, is much more complicated than reading acquisition in many other languages, due to its deep orthography (see Seymour, Aro, & Erskine, 2003). The English language contains many irregularities and inconsistencies which make it so that graphemes and phonemes do not always directly correspond. These inconsistencies make the whole

word method a very demanding task requiring children to memorize every word they encounter.

On the contrary, synthetic phonics approaches, in which children learn the smallest units of language (graphemes and phonemes), seem to be the most logical way to teach the English language and support early reading development (see Seymour & Duncan, 1997). There is ample support for synthetic phonics programs among native speakers of English (ex. Johnson & Watson, 2005). Strong evidence in favor of synthetic phonics programs have also been found for children learning English as a second language. A study by Stuart (1999) looked at reading instruction for 5-year-old children through a synthetic phonics program, Jolly Phonics, versus a more holistic program which placed no explicit importance on phonics. Majority of the sample (N=96 out of 112) were children who were learning English as a second language. Results showed a significant positive effect of the Jolly Phonics intervention on the children's reading and writing development which persisted even a year after the initial intervention. Based on these results, researchers concluded that early structured, rapid, and focused teaching of phonetic manipulation actively supports development of this knowledge, even for children who are non-native speakers of the language (Stuart, 1999). A follow up study by Stuart also showed that even if children have not been taught using phonics at the start of school, they can catch up through structured and intensive phonics training (Stuart, 2004).

Based on their success, synthetic phonics approaches have made their way to developing countries more recently; India being one such country of study. Dixon and colleagues tested the Jolly Phonics intervention with children attending English-medium, low-income private schools in Hyderabad, India. There was an experimental group which received the intervention for an hour per day for 6 months by the teacher, and a control group which received the traditional English instruction. Results showed a statistically significant difference between the experimental and control groups, with the experimental group performing better on tasks of reading, spelling, and sounding out letters and words (Dixon et al., 2011).

Finding such as these strongly support the idea that phonics interventions could be successful to improve emergent English literacy in India. Not only do we see that phonics interventions can be used with children learning English as a second language, but also that it can be successful with children living in slum environments and with those who have illiterate parents.

6 THE GRAPHOLEARN METHOD

GraphoLearn, previously known as GraphoGame, is a theoretically driven computer-assisted reading intervention that provides letter-sound training to children with the aim of improving children's phonemic awareness. It was originally devised for readers of transparent Finnish based on longitudinal data that was collected through the Jyväskylä Longitudinal Study of Dyslexia (Lyytinen, Erskine, Kujala, Ojanen, & Richardson, 2009; Lyytinen, Ronimus, Alanko, Poikkeus, & Taanila, 2007; Richardson & Lyytinen, 2014). The Finnish version of GraphoLearn was later adapted to other languages around the world, English being one.

GraphoLearn English is based on a theory of teaching small units, or individual phonemes first, as this phonetic knowledge has been shown to be a strong predictor of later reading skill (Hulme et al., 2002; Seymour & Duncan, 1997). There is a consistent presentation of the sounds in that first the single grapheme-phoneme correspondences are taught, then these are blended into larger units, and finally words are created. Later in the game, players are also shown whole words in which they must isolate or blend various grapheme-phoneme correspondences. Presentation of the grapheme-phoneme correspondences is done starting from the most frequent and consistent to the least (Kyle, Kujala, Richardson, Lyytinen, & Goswami, 2013). Overall, GraphoLearn has shown promising results in many countries across various languages (Brem et al., 2010; Kyle et al., 2013; Lyytinen et al., 2009; Ojanen et al., 2015; Saine, Lerkkanen, Ahonen, Tolvanen, & Lyytinen, 2011).

Prior to the current study, there has only been one study done so far using GraphoLearn English. Kyle and colleagues tested the efficacy of GraphoLearn on students who were native English speakers in the UK. They were able to show significant improvement in basic reading skills of the intervention group as compared to the controls (Kyle et al., 2013). Till date, there has been no study which has used GraphoLearn to support non-native speakers of a language. However, based on previous research that has shown that synthetic phonics programs can be successful with English language learners (Dixon et al., 2011; Stuart, 1999; Stuart, 2004) and GraphoLearn's success as an intervention, we would expect some effect as a result.

7 WHY TECHNOLOGY?

India has always been a strong player in the IT industry (Kingdon, 2007; Mitra et al., 2003), and with technology becoming more and more affordable and accessible, it is only natural to see technology use in the classroom as well. Today, the tablet market in India is growing annually at a rate of 75% and smart phones are becoming more popular as low-cost models have come on the line (Central Square Foundation, 2015) allowing for anytime, anywhere access to education. There are a number of organizations (ex. Nalanda Project by Motivation for Excellence Foundation) and companies (ex. Educational Initiatives Pvt. Ltd.) working to bring technology into the classrooms of India. Researchers have found that not only is technology-led instruction benefiting children's learning, it is also cost effective and time effective (Muralidharan, Singh, & Ganimian, 2017). In a country like India where all resources are constantly in strain, time and money are invaluable.

Muralidharan et al. (2017), showed the positive effects of using a technology-aided after-school instruction program to support the improvement of children's math and language test scores. They attribute their positive results to the intervention providing high quality content and having effective delivery which

personalizes instruction for the students. These are all constraints that are seen in a typical Indian classroom which they believe contribute to low productivity. Insights from studies across the educational technology sector in India have shown the benefits of, and continuing need for, technology that allows for differentiated instruction through personalized learning. More specifically, it should allow for instant data on students and which provides support in learning language skills for English (Central Square Foundation, 2015). Both the intervention used by Muralidharan and colleagues, and applications such as GraphoLearn can support teachers in the classroom by allowing for differentiated student instruction and real-time feedback (Ojanen et al., 2015). In classrooms where teachers are already faced with the problem of large class sizes and heterogeneous student populations, an application like GraphoLearn has immense potential to be a successful support for both students and teachers.

8 THE PRESENT STUDY

As it can be seen, there are a number of factors working against slum community children in India, when it comes to learning to read in English. Coming from homes where parents may also be illiterate, children are suddenly forced to learn in a language which they may have no prior exposure to. Mother tongue instruction also may not be seen as an ideal option in a place like India, where English is given such high importance and has the potential to open many more doors. However, the rote methods teachers are currently using are clearly not helping students to achieve. Thus, putting children in a situation where, although they are attending English medium schools, they many never acquire sufficient English literacy, and therefore may never be able to break out of the cycle of poverty. The few studies which have been done using synthetic phonics instruction to teach English in India have produced promising results (Dixon et al., 2011). However, due to the demands faced by teachers in India such as large class sizes and limited resources, such instruction

may seem like a burden. Technology may help us to overcome some of these barriers while allowing us to provide the high-quality literacy instruction that all children deserve.

In this study, we will be using a computer-assisted reading intervention, GraphoLearn, to determine whether such an intervention can be successful in improving English grapheme-phoneme knowledge, reading, and spelling ability of slum children in India. We will be using a Grade 3 classroom in an English medium government-aided public school in Ahmedabad, Gujarat, India. We have chosen Grade 3 because we can assume that these children will have had at least two prior years of spoken English exposure (starting from Grade 1). Based on previous studies using synthetic phonics and based on previous GraphoLearn studies, we do expect to see improvement in student's performance.

8.1 Ahmedabad, Gujarat, India

With a population of about 5.6 million people, Ahmedabad is the seventh largest city in India and the largest city in the state of Gujarat. Despite being home to many prestigious science and education institutions, Ahmedabad still has an illiteracy rate of over 21%, leaving more than a million of its inhabitants as illiterates. There are numerous independently-run private schools which are available for those families who can afford to pay the required fees for admission. For those who cannot afford high-income private schools, there are both low-income private schools and government-aided public schools. The government offers schooling options in Gujarati (the state language) as well as Hindi and English.

8.2 Teach for India

Teach for India is a non-governmental organization that has been working since 2009 across various cities in India with a vision that, "one day all children will attain an excellent education" (see www.teachforindia.org). In order to achieve this, they

select young leaders from across the country to become fellows. Fellows are then placed in low-income private and public schools which have teacher shortages. Teach for India only intervenes in English medium schools and fellows spend two-years as full-time teachers in their classrooms. Training for the fellows is provided by Teach for India as most do not come from teaching backgrounds. Curriculum and materials are also provided by Teach for India, however, it is up to the fellow and the school to decide on what material is to be taught. It is expected that Teach for India fellows only speak English in the classroom and all subjects are taught in English by the fellow. Hindi and state languages classes are then taken by another teacher within the school. For this study, the both the pilot and full study were done in a Teach for India classroom meaning that the children have been taught by Teach for India hired teachers since Grade 1. This decision was made solely for the reason that we can more confidently say that these children have been exposed to spoken English from their teacher prior to the start of the study.

9 METHODS

GraphoLearn was provided as a supplement in a Grade 3, government-aided public school classroom in Ahmedabad, Gujarat, India. The school was approached based on information retrieved from the class teacher which showed the children as having very low literacy levels. Permission to run the study was taken from the Ahmedabad Municipal Corporation School Board, along with the principal and the class teacher.

9.1 Pilot

Prior to the start of the full study, a small pilot was conducted including 16 children from a second government-aided public school. These students were also in Grade 3 and had similar demographics as the children who participated in the full study. The pilot phase was run for two weeks and the primary purpose of the pilot phase

was to experience the type of difficulties which may arise in the full study in a hope to circumvent such difficulties later. After the pilot period, there were some changes that were made prior to the start of the full study. The math game was changed for the controls as the original game which was selected was not long enough for students to play throughout the entire study period. Another change was to the paper-pencil tasks. It was originally planned to conduct a standardized phoneme deletion task as used by Kyle and colleagues (Kyle et al., 2013) however, when attempted with the children during the pilot, it could be seen that children did not understand the task as stated by the directions. Therefore, the standardized phoneme-deletion task was not included in the full study.

9.2 Participants

Thirty-one third graders, ages 7-8 participated in the study. Data provided by the teacher showed that the children, on average, were performing drastically below grade level in literacy. Due to the lack of specialists in the school, it is unknown if any children had additional learning needs and no students had any formal diagnoses. All of the participating students were consented at the end of 2nd grade before they left for summer holidays to ensure that the study could begin as soon as possible once they returned. Parents were invited to the school and taken through the consent form as many were illiterate in English (see Appendix 1 for consent form). In total, 43 parents consented, however, only 31 children ended up participating in the study as some children dropped out of the school prior to the start of the study while other children had extremely irregular attendance or joined the school after the start of the study and therefore could not be included.

Students were randomly selected for either the experimental group which played GraphoLearn (n=16) or the control group which played a math game (n=15). Groups were primarily matched based on age and gender. They were also matched on basic reading skills, such as letter-sound knowledge, based on the information provided by the teacher. All students came from low-income homes, with a majority

living below poverty line and all students were learning English as a second or third language, with no exposure at home to English. All the children, except for one, had been enrolled in the school from Grade 1 and they had all been in the same classroom with the same teacher in both Grades 1 and 2. At the end of the study, there were 3 students who were unable to participate in all or some parts of the post-test due to illness. One student's data from the control group has been removed because they did not participate in any of the post testing. The other 2 students' data, both of whom were in the GraphoLearn group, was not removed because 1 participated in the GraphoLearn post-tests and the other participated in the paper-pencil post-tests. Significance values and effect sizes were not affected by eliminating these students' data, and therefore their data has been retained. Final group sizes at post-test were n=16 for the GraphoLearn group and n=14 for the control group. As a reward for the participation and cooperation of the class teacher and students involved, a set of 20 English story books were donated to the classroom at the end of the intervention period.

9.3 Procedure

Both groups of children played their respective games (GraphoLearn vs. Math) for 20-30 minutes per day, 6 days a week, over a period of 8 weeks. The children played the game on an individual tablet with headphones. All play was done during the regular school day where children were pulled out of their classroom in batches of 12 and then taken to a separate room where the tablets were set up for them. The researcher was present during all play sessions with the students.

9.4 GraphoLearn

GraphoLearn English requires players to create an individual avatar after which they are taken through a series of levels which are divided into streams. In total, there are 25 streams which contain anywhere from 5 to 9 levels each. After every 4

streams, there is an assessment stream in which players are assessed on letter-sounds, rime units, and word recognition. Players are presented with individual grapheme-phoneme correspondences first. These are then blended into larger units, which can then be used to form words. GraphoLearn provides adaptive practice in which players both see the letter or letter string, and hear the speech sounds. They are expected to select out of 4-5 possible options. If they choose incorrectly, they are provided with automatic feedback, allowing them to correct themselves. Players must score above an 85% on each level within a stream in order to move on to the next stream. Players are rewarded with stars and coins which they can trade in to purchase things for their avatar. Data from the game is automatically saved to an external server when players exit the game so long as the device has an active internet connection.

9.5 Math Game

The math game played by the control group was a 3rd grade-level math game selected from the Google Play store. It provided students with basic operations problems (addition, subtraction, multiplication) and students were required to select the answer out of 4 targets provided. Students could select out of 3 degrees of difficulty (easy, medium, hard) and their progress in the game was saved meaning they could continue every session where they last left off. The math game was similar to GraphoLearn in that within each level there were multiple sublevels. The game rewarded children with stars and children were instructed to move on to the next level only after collecting at least two stars. The game provided no visual or auditory English input other than at the beginning when children had to select their level. The main purpose of the math game was to ensure that both groups of children spent equivalent amounts of time in the classroom versus outside of the classroom using the technology. As it can be seen in Table 1, there were no significant differences in the play days and times between the two groups.

TABLE 1 Group Characteristics

Characteristic	GraphoLearn	Control	
n (Pre-Test)	16	14	-
n (Post-Test)	15	14	-
Gender (Male, Female)	8, 8	7, 7	-
Age (months)	91.94 (.629)	91.00 (.839)	t(28)=.91
Playing Time (min)	470.7 (40.8)	457.3 (68.0)	t(20.7)=.64
Playing Days	21.3 (1.7)	20.8 (3.1)	t(19.5)=.50

9.6 Measures

To determine efficacy of the intervention, students were assessed at pre and post intervention using three tasks in the GraphoLearn software. The in-game assessment found in the GraphoLearn software was made up of three tasks; the first which tested letter-sound knowledge, the second which tested rime unit recognition, and the third which tested whole word recognition. Three standardized paper-pencil tasks for reading, and one paper-pencil task for spelling were also used to see if the skills learned while playing GraphoLearn were being transferred. Students completed 3 reading tasks; the Single Word Reading subtest from the British Ability Scale (BAS), and the Test of Word Reading Efficiency (TOWRE) which included sight word reading and non-word reading. Students also completed a modified version of the spelling subtest from the BAS.

9.6.1 In-Game Assessments

All students played the in-game assessment in GraphoLearn. As mentioned, the assessment contains three separate tasks. The letter-sound task requires children to pick the correct letter, out of 4-5 options, that correspond with the sound which is presented to them. The rime unit task requires children to pick the correct 2-3 letter

string that corresponds to the pronunciation presented to them. Finally, the word-recognition task requires children to pick the correct word to that which is presented to them. In all three tasks, players are presented with an auditory target which they then must match with a visual target, just as in the rest of the game. Both the experimental and control groups completed the assessment level prior to and at the end of the intervention period.

9.6.2 Reading

All students in the study completed the Single Word Reading subtest from the British Ability Scale (BAS; Elliot, 1987) which measures single-word reading accuracy. The test was administered according to the manual and requires children to read single-words of increasing difficulty which are listed in groups of 10. The test is discontinued after children miss 8 or more words within one group. Internal reliability of the BAS word reading task has been reported to be .98 as per test review (Thomson, 1997). Students also completed the Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner, & Rashotte, 1999). The TOWRE requires students to accurately read aloud a list of sight words and non-words in 45 seconds. Practice words were given for each section. Reliability has been reported to be .91 for the sight words task and .92 for the non-words task as per test review (Tarar, Meisinger, Dickens, 2015). It is important to note that these assessments are not standardized for Indian children and therefore only raw scores are provided.

9.6.3 Spelling

All students also completed a spelling subtest which was taking from the BAS. The task contains a mixture of verbs, nouns, and adjectives, some of which can be spelled phonetically. The dictation test was not followed according the directions which has different starting points based on age. Rather, the first 30 words out of the list were dictated to all students with the accompanying sentence. The word and or sentence were said a maximum of 3 times and students were expected to write down the

word. Final scores are reported as the raw score out of 30 which students were able to spell correctly. (See full dictation list in Appendix 2)

9.7 Fidelity to the Program

Fidelity to the GraphoLearn intervention is controlled by the game which sends detailed player logs to the GraphoWorld server. These logs include the number of days played and seconds spent playing. The first and last play day are also recorded. For the control group, days and time (in minutes) were recorded manually by the researcher.

10 RESULTS

Prior to analyses, the distributions of all measures were assessed for normality. The BAS reading measure at pre-test had two scores which were outliers and caused a right-skewed distribution. The TOWRE non-words measure at pre-test had one score which was an outlier and caused a right-skewed distribution. These scores were winzorized (replaced with a value that was closer to the distribution while retaining the order of values) to meet the assumption of normality. The remaining measures (GraphoLearn letter-sounds, GraphoLearn rime units, and GraphoLearn word recognition, TOWRE sight words, spelling) all resembled a normal distribution at both time points.

Pre-Test and Post-Test Group Comparisons

The pre-test and post-test means and standard deviations in the two study groups, as well as group comparison results, are reported in Table 2 for the GraphoLearn tasks and Table 3 for the paper-pencil tasks. First, an independent samples t-test was conducted to examine if there were group differences at pre-test or post-test. Due to

the small sample size, group differences were also analyzed using non-parametric measures (Mann-Whitney U), however the results did not differ from those given by the t-test and therefore, t-test results are reported. Effect sizes at pre-test were also calculated for all measures using Cohen's *d*. The criteria as that defined by Cohen (1988) is being used in which $d \geq .2$ is a small effect, $d \geq .5$ is a medium effect, and $d \geq .8$ is a large effect.

The results showed that there were no pre-test group differences in the GraphoLearn tasks (see Table 2). Effect sizes were small for letter-sounds (.30), rime units (.18), word recognition (.08) and supported the t-test finding of insignificant group differences at pre-test.

At post-test, group differences were significant for all GraphoLearn tasks; letter-sounds ($t(27)= 5.73$, $p= .000$), rime units ($t(27)= 2.31$, $p= .029$), and word recognition ($t(27)= 2.07$, $p= .048$). Effect sizes were also large for GraphoLearn letter-sounds (2.51) and GraphoLearn rime units (.86), and medium for GraphoLearn word recognition (.77).

On the paper-pencil tasks, results showed that there were no significant differences between the groups at neither pre-test nor post-test. Effect size (*d*) for the group differences at pre-test was very small and supported the t-test finding of no group differences in BAS reading (.13), TOWRE sight words (.24), TOWRE non-words (.23), and spelling (.24). Effect size for the paper-pencil tasks at post-test were also very small and again supported the t-test finding of no group differences in BAS reading (.03), TOWRE sight words (.08), TOWRE non-words (.09), and spelling (.05).

Group Comparisons of Development from Pre-Test to Post-Test

Repeated measures ANOVA was used to compare the effects of time (change from pre-test to post-test), group (GraphoLearn vs. control), and time*group interaction on the development of scores (group differences in change).

For the GraphoLearn tasks (letter-sounds, rime units, and word recognition)., there was again a significant main effect of time on all three tasks (See Table 2), with

both groups showing changes from pre- to post-test (see Figure 1). For the letter-sounds task, there was a significant main effect for group ($F(1,27)= 12.95$, $p= .001$), as well as an interaction effect for time*group ($F(1,27)= 44.87$, $p= .000$), with the GraphoLearn group showing significantly higher scores as compared to the control group. Although close, on the rime unit task, there were no significant main effects for group ($F(1,27)= 3.09$, $p= .09$), nor were there significant interaction effects for group*time ($F(1,27)= 3.13$, $p= .09$). Finally, for the word recognition task there were no significant group effects, ($F(1,27)= 1.09$, $p= .32$), nor were there significant interaction effects for group*time ($F(1,27)= 2.68$, $p= .11$).

For the paper-pencil tasks (BAS reading, TOWRE sight words, TOWRE non-words, and spelling), there was a main effect for time on all measures (see Table 3), with both groups showing improvements from pre to post-test (see Figure 2). There were however no significant effects of group, nor were there significant time*group interactions on for the paper-pencil assessments.

TABLE 2 Descriptive Statistics and Group Comparisons on GraphoLearn Tasks

Measure	Assessment	GraphoLearn *M (SD)*	Control *M (SD)*	*t*	Group Effect	Time Effect	Interaction Effect
Letter-sounds	Pre-Test	33.3% (11.2)	36.3% (8.7)	$t(28) = -.81$			
	Post-Test	63.9% (18.0)	32.1% (10.6)	$t(27) = 5.73^{***}$	$F(1,27) = 12.95^{***}$	$F(1,27) = 25.91^{***}$	$F(1,27) = 44.87^{***}$
Rime Units	Pre-Test	16.6% (16.7)	13.6% (15.6)	$t(28) = .50$			
	Post-Test	39.4% (20.5)	23.2% (17.0)	$t(27) = 2.31^{*}$	$F(1,27) = 3.09$	$F(1,27) = 18.24^{***}$	$F(1,27) = 3.13$
Word Recognition	Pre-Test	30.7% (16.3)	29.2% (19.8)	$t(28) = .23$			
	Post-Test	49.0% (12.1)	39.1% (13.5)	$t(27) = 2.07^{*}$	$F(1,27) = 1.03$	$F(1,27) = 25.13^{***}$	$F(1,27) = 2.68$

$^{*}p \leq .05$, $^{**}p \leq .01$, $^{***}p \leq .001$

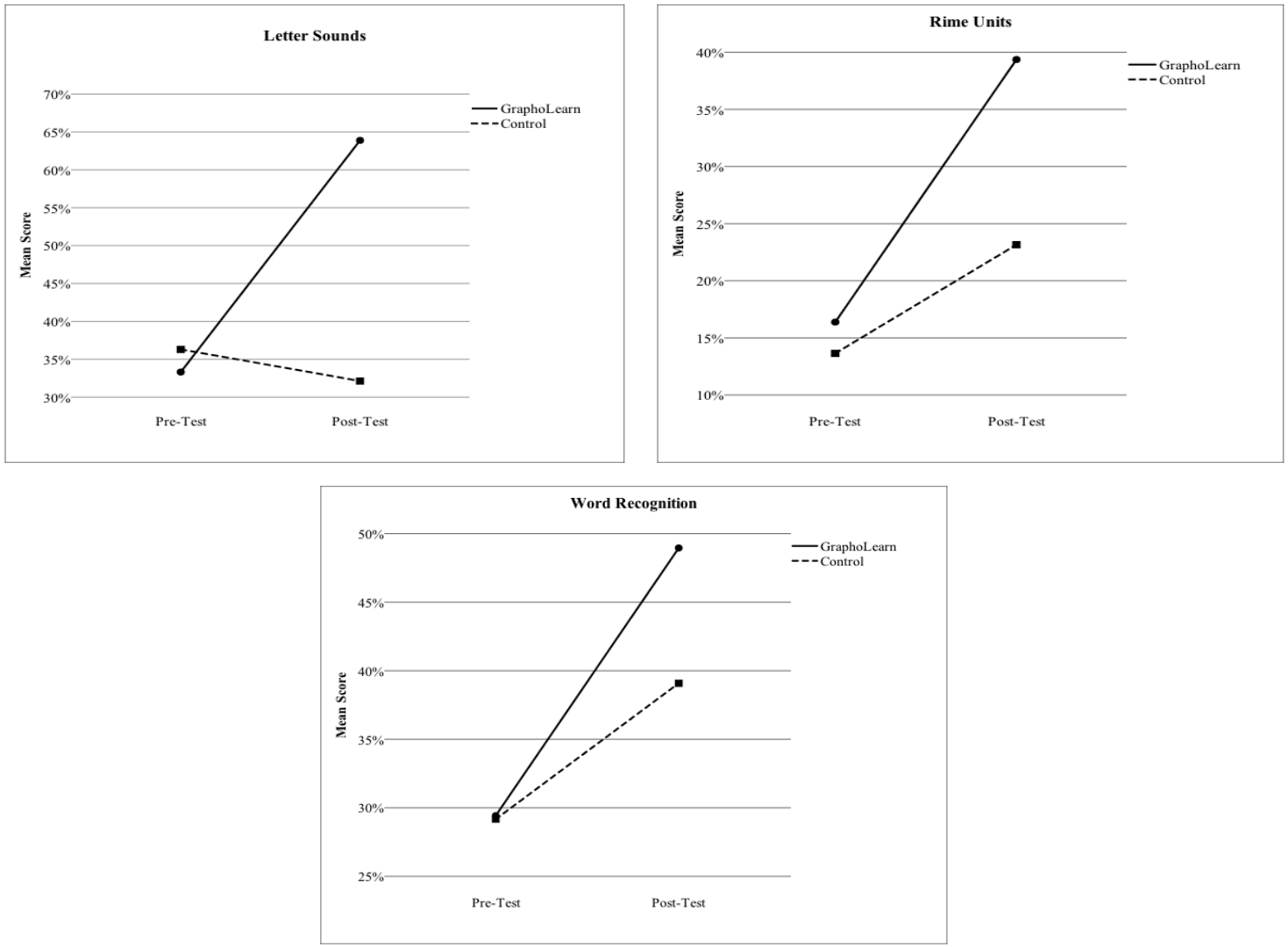
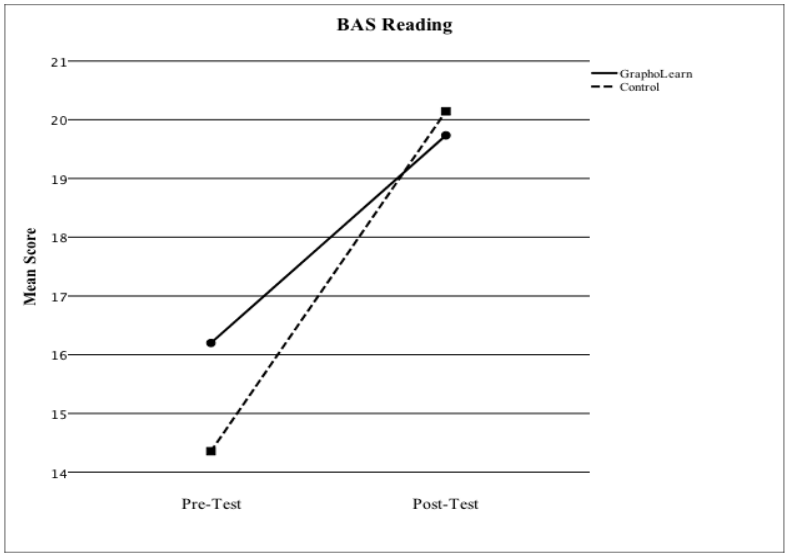


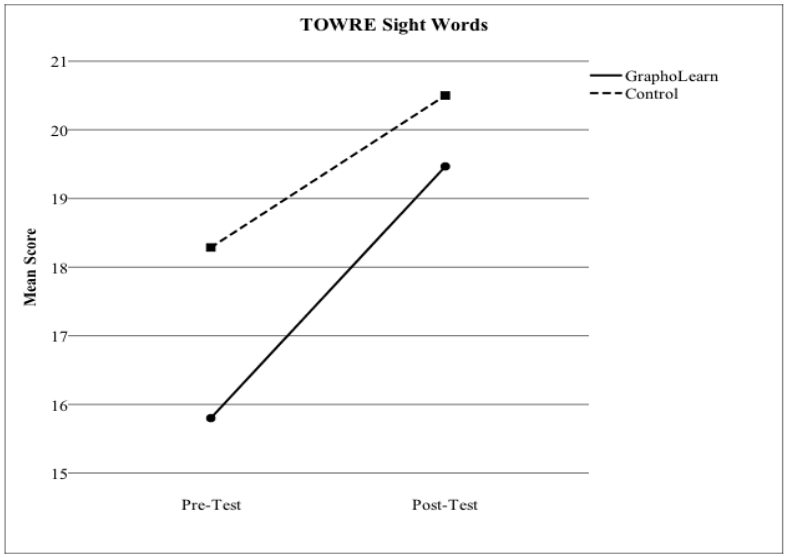
FIGURE 1 Group Comparisons of Development from Pre-Test to Post-Test on GraphoLearn Tasks

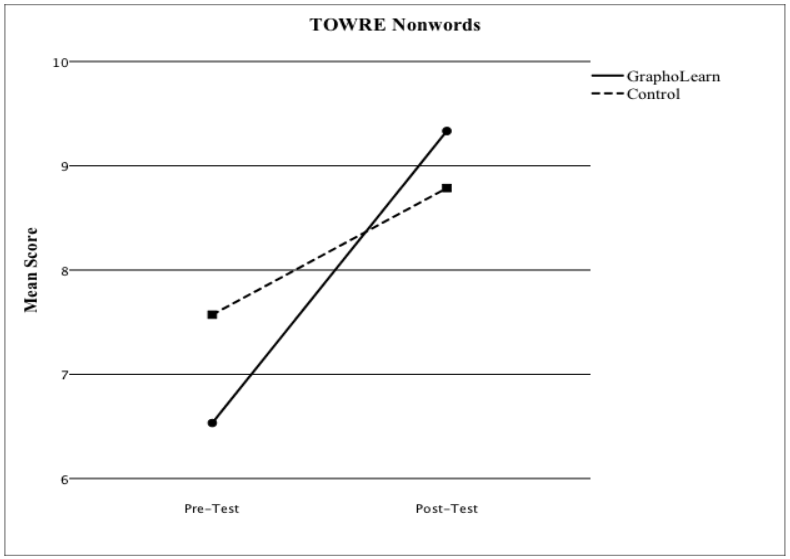
TABLE 3 Descriptive Statistics and Group Comparisons on Paper-Pencil Tasks

Measure	Assessment	GraphoLearn *M* (*SD*)	Control *M* (*SD*)	*t*	Group Effect	Time Effect	Interaction Effect
BAS Reading	Pre-Test	15.9 (11.5)	14.4 (12.0)	*t*(28)= .72			
	Post-Test	19.7 (13.7)	20.1 (18.6)	*t*(27)= -.07	*F*(1,27)= .02	*F*(1,27)=12.39**	*F*(1,27)= .72
TOWRE Sight Words	Pre-Test	15.6 (9.2)	18.3 (13.7)	*t*(28)= -.63			
	Post-Test	19.5 (12.8)	20.5 (13.2)	*t*(27)= -.22	*F*(1,27)= .15	*F*(1,27)= 10.98**	*F*(1,27)= .67
TOWRE Non-Words	Pre-Test	6.5 (4.2)	7.6 (4.9)	*t*(28)= .53			
	Post-Test	9.3 (6.3)	8.8 (6.4)	*t*(27)= .23	*F*(1,27)= .02	*F*(1,27)= 7.86**	*F*(1,27)= 1.23
Spelling	Pre-Test	10.1 (8.5)	12.2 (8.9)	*t*(28)= -.66			
	Post-Test	13.7 (8.1)	13.3 (8.6)	*t*(27)= .12	*F*(1,27)= .09	*F*(1,27)= 11.95**	*F*(1,27)= 3.67

*$p \leq .05$, **$p \leq .01$, ***$p \leq .001$







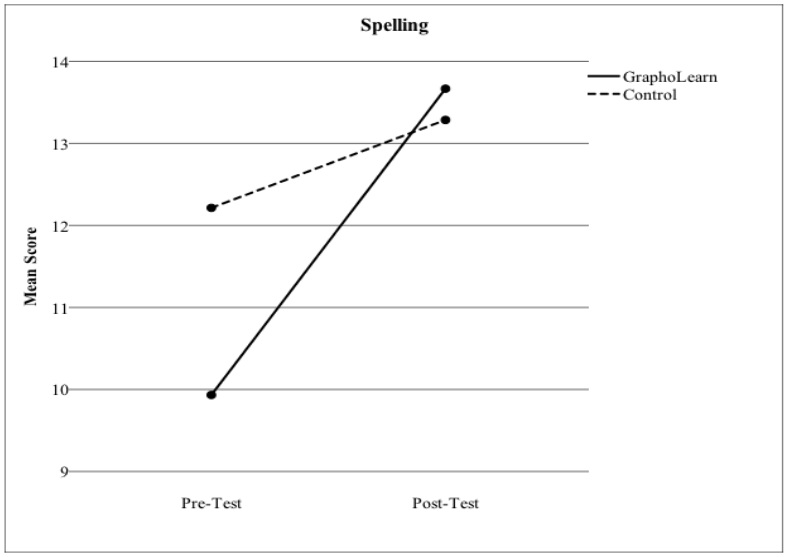


FIGURE 2 Group Comparisons of Development from Pre-Test to Post-Test on Paper-Pencil Tasks

Group Comparisons of Gain Scores

Finally, groups were compared using gains scores. Gain scores were calculated by subtracting the pre-test score from the post-test score for each individual. Means and standard deviations of the gain scores for both groups are given in Table 4, along with group comparisons, and effect size (Cohen's *d*) for GraphoLearn versus control. The standard errors of the effect sizes are given in parentheses.

In regards to the GraphoLearn tasks, there was a very large effect on the letter-sound (2.98) as well as medium effects for the rime units (.64) and word recognition (.52) tasks. In regards to the paper-pencil tasks, GraphoLearn group versus control group comparison had medium effect sizes on TOWRE non-word reading (.62) and spelling (.74). Effect size was small for TOWRE sight word reading (.31) but almost zero for BAS single-word reading.

TABLE 4 Means and Effect Size of Gains

Measure	GraphoLearn *M* (*SD*)	Control *M* (*SD*)	*t*	Effect Size *d* (*SE*)
n	15	14		
GL Letter-sounds	30.57% (15.78)	-4.17% (11.67)	*t*(27)= 6.70***	2.98 (.35)
GL Rime Units	22.98% (19.82)	9.51% (21.16)	*t*(27)= 1.77	.64 (.24)
GL Word Recognition	19.53% (13.01)	9.91% (18.35)	*t*(27)= 1.64	.52 (.18)
BAS Reading	3.53 (7.03)	3.43 (4.09)	*t*(27)= .05	.02 (.44)
TOWRE Sight Words	3.67 (1.25)	2.21 (4.71)	*t*(27)= .82	.31 (.27)
TOWRE Non-Words	2.80 (4.04)	.64 (3.46)	*t*(27)= 1.54	.62 (.30)
Spelling	3.73 (3.86)	1.07 (3.61)	*t*(27)= 1.92	.74 (.28)

***$p \leq .001$

11 DISCUSSION

The link between phonemic awareness and early reading development is one which has been established for more than two decades now (see Hatcher et al., 1994; Torgesen et al., 1999). In response to such evidence, further research has been done, particularly in first world countries, to study effective interventions which can be used to develop phonemic awareness in children and prevent later reading failure (see Foorman, Francis, Fletcher, Schatschneider, & Mehta, 1998; Hatcher, Hulme, & Snowling, 2004; Vandervelden & Siegel, 1997). However, much less is known about effective literacy instruction in the developing world where the need is high, but access is low.

The present study examined whether GraphoLearn, a computer-assisted reading intervention, could effectively support the development of basic English reading skills of struggling readers in India. GraphoLearn has proven to be a successful support in Finnish (Lyytinen et al., 2007; Lyytinen et al., 2009) as well as German (Brem et al., 2010). Kyle and colleagues were the first to successfully test GraphoLearn in English, which as a nontransparent orthography, often proves harder to learn (Seymour et al., 2003). The current study pushed the boundaries of GraphoLearn to look at whether it could successfully support slum children in India who were learning English as a non-native language and who typically had no exposure to English outside of the school environment. The sample was made up of 30 students who had just entered Grade 3 and were attending an English medium public school in Ahmedabad, India. Students were divided into either the control or experimental group with the control group playing a simple math game and the experimental group playing GraphoLearn for 20-30 minutes per day, over a period of 8 weeks. Both groups were pre and post-tested on various measures of reading and spelling.

Despite a short play period (~ 7.5 hours), participant made significant gains and effect sizes were promising for almost all measures. The GraphoLearn intervention group showed the greatest improvements on the letter-sound task. These results show that GraphoLearn can effectively support the development of English letter-sound

knowledge in Indian children, despite the fact that children are non-native speakers and were exposed to the intervention for a limited amount of time. The ability for GraphoLearn to support letter-sound knowledge to this extent is of importance as letter-sound knowledge has been identified as a critical building block in early reading development, even for non-native readers of English (Muter & Diethelm, 2001). There is also causal evidence in favor of phonemic awareness and letter-sound knowledge affecting early literacy skills, particularly word reading (Hulme, Bowyer-Crane, Carroll, Duff, & Snowling, 2012). If this is the case, then GraphoLearn can be seen as a beneficial intervention for such children as studies have shown bilingual children benefit just as much as native English speakers when they are provided with literacy interventions that involve explicit emphasis on grapheme-phoneme relationships (Lesaux & Siegal, 2003).

On the rime unit and word recognition tasks, group differences were not significant but effect sizes were still medium to large. This suggests that with a larger sample, effects may have reached significance. Lack of significance may, however, also be partially explained by the progression of the game. As mentioned, the progression of GraphoLearn introduces children to all the single grapheme-phoneme correspondences first, before moving to consonant-vowel or vowel-consonant units; whole words are then introduced even later (Kyle et al., 2013). Due to limited play time, most children were exposed to letter-sound levels but some did not reach, or reached late, the levels which allowed them sufficient practice with rime units and whole-word recognition. Further studies are required to determine if greater play time will produce significant effects on the GraphoLearn rime units and word recognition tasks.

Paper-pencil measures of reading and spelling were conducted to determine if there was a transfer of skills learned in-game to a non-game assessment. Effect sizes on the paper-pencil tasks were of medium size and comparable to the rime unit and word recognition in-game tasks, as well as to those found by Kyle et al. (2013) for GraphoLearn tested on native English speakers and as seen in other intervention studies (Torgesen, Wagner, Rashotte, Herron, & Lindamood, 2010). Effects, although not particularly strong, were double on the TOWRE sight words and non-words tasks, compared to those reported by Kyle et al (2013). This was a particularly surprising finding considering that

these were tasks which were standardized for native speakers of English. Suggesting that if there would have been standardized assessments for Indian ESL children, effects could have been even stronger. Nonetheless, the results show that skills learned in GraphoLearn can transfer to non-game settings even for children who are non-native speakers of English.

Improvement on the sight word task is in line with research showing that phonemic awareness and letter knowledge both play an active role in supporting sight word reading of early readers (Ehri, 2014). Improvements in non-word reading support findings by Lesaux and Siegal (2003) who had ESL readers out-performing native English speakers on numerous tasks, including non-word reading. They concluded that these improvements can be attributed to the heightened metalinguistic awareness that ESL students display as they acquire English, which in turn leads to higher phonemic awareness. If children who are learning English as a second language do in fact have a heightened sense of phonological awareness, then we may actually see that GraphoLearn English can be more successful for bilingual or multilingual learners of English than even native speakers' due to the repetitive exposure it provides to grapheme-phoneme correspondences. To go beyond just word reading, participants' improvement in spelling was also assessed. Effect sizes for spelling were similar to those found by Kyle et al. (2013) and show that the skills learned within GraphoLearn were also supportive of spelling development even in the Indian children. This success can again be attributed to heightened phonemic awareness which plays an active role in childrens' spelling ability (Caravolas et al., 2012; Griffith, 2001).

Overall, the intervention produced very promising results for success in the Indian context where the importance of English grows, yet supports for learning the language are lacking. Effectiveness was comparable with the few interventions studies that have been done using phonics programs in the Indian setting (e.g. Dixon et al., 2011; Nag-Arulmani et al., 2003), with comparatively less demand of resources. GraphoLearn, as an intervention, works by combining successful aspects of previous interventions, while providing individualized learning for students and easy to access data for teachers, factors crucial for implementation and success in a country like India (Central Square

Foundation, 2015; Muralidharan et al., 2017). Generalizability of these results will be of question and therefore, it is important that going forward, further testing be done to determine if results improve when the GraphoLearn is used over a longer period of time, with a larger population, and in other parts of India where demands may differ. Nonetheless, this study provides a good first step in looking at how technology, and in particular GraphoLearn, can be used to support the English reading skills of struggling readers in India.

11.1 Limitations

There are a few limitations that must be taken into consideration when evaluating the results of this study. One major limitation was a small sample size. With a sample size of only 30 children, we were limited by the statistical approaches that could be used on the data. With a bigger sample, we would have had more statistical power. Sample size also affected the ability to measure reliability of the GraphoLearn tasks. A second limitation was limited intervention time. Although the study was carried out over 8 weeks, the students only played for about 7.5 hours. Most inability to play was due to student absenteeism and/or the school being unexpectedly closed. Due to limited play time, no student was able to complete all the streams. Although these factors limit the results of this study, such problems are very real for teachers in India. Therefore, what we see as limited may be what we would actually see if teachers were expected to carry out such and intervention themselves. Third, a limitation from the point of view of practical implications was the full-time presence of a researcher during the intervention period. The presence of an adult who was fully focused on the participating children may have increased motivation. The researcher was also constantly supporting students by calling them if they were not in school and making it possible for them to play any time of the school day. In implementation of the game in everyday practices these conditions are not realistic. It is important that futures studies take into consideration the realities of implementation as to increase chances of sustainability (Central Square Foundation, 2015). Finally, based on the current study, we do not know how the effects will be

maintained over time. In future studies, it would be important to conduct follow-ups and determine whether or not effects are maintained by students even post-intervention.

11.2 Practical Implications

The current study sheds insight into the ability of computer-assisted reading interventions, like GraphoLearn, to support children who struggle to read in India. A logical next step would be to test GraphoLearn English on a larger scale over a longer period. As mentioned previously, the exposure time of students to the game was quite limited due to many uncontrollable factors. Thus, future studies should focus on exposure over a longer duration to determine whether that boosts effects and leads to students being able to transfer the skills they learn in the game to real life situations.

GraphoLearn also opens doors to the ability to provide interventions in children's mother tongue and other native languages. According to the 2001 census, 41% or more than 422 million individuals are Hindi speakers. Despite the large number of speakers, there is still a great need for EdTech developers to cater to students who are studying in a native language in India (Central Square Foundation, 2015). By now it has become clear that technology has potential to enhance learning, particularly in developing countries where differentiation is necessary, but difficult for a teacher alone to achieve (Muralidharan et al., 2017). However, there are still critical considerations that must be taken into account prior to implementing technology in schools. According to The World Bank (2018), technology should be used as a complement to teachers rather than a replacement for teachers. A study in India where children were provided technology as a teacher substitute within the school versus a teacher compliment out of school showed that children in the within school group learned significantly less (Linden, 2008). As suggested by Muralidharan, Singh, and Ganimian (2017), it may be most efficient if technology is used to create what they call a "blended learning" environment in which teachers use the information that they can gather from the technology to guide further instruction. In the current study, GraphoLearn was used as an in-school intervention. However, there was no teacher involvement and therefore it became an isolated activity

that the children performed during the day. In a previous study which looked at the effectiveness of GraphoLearn in Zambia, it was shown that an intervention design in which both students and teachers were trained on and played GraphoLearn lead to the greatest improvements in student learning (Jere-Folotiya et al., 2014). GraphoLearn could provide teachers with an alternative to the currently used "whole-word" approach to teaching English and thus, going forward, it must be considered how the technology can be used in greater collaboration with teachers as well.

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APPENDICES

Appendix 1: Participant Consent Form

JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

CONSENT AND EXAMINATION FORM

GraphoGame English
Reading Support for Children-India

Name of Child: ……

Age: ……Sex: ……Code: ……..

School: ……

Dear Parent/Guardian,

My name is Priyanka Patel. I am a Master's degree student at the University of Jyväskylä in Finland. I am currently conducting a study looking at GraphoGame English as a reading intervention for children in India. The main aim of this research is to determine whether GraphoGame English is effective at improving English reading skills of children in English medium schools in India.

Your child's classroom has been selected to take part in this study and we request your permission to enable your child to take part. Should you agree, your child will be participating by playing GraphoGame on the tablet for 15-20 minutes per day, 6 times a week, for a specified period of time. They will also be participating in some paper-pencil exams to assess their progress.

Risk and Benefits: There are no risks involved in this study. Benefits are that your child will be exposed to a new way of learning how to read as well as get a strong start to the new school year. Your child will also benefit from the knowledge the class teacher will acquire through this research.

Participation Rights: Your consent is being given voluntarily; you may refuse to allow your child to participate in the entire study or any part of the study. You are also free to withdraw your child from participation at any time during the study.

JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

CONSENT AND EXAMINATION FORM

GraphoGame English
Reading Support for Children-India

Declaration by parent/guardian:
I have read and understood this confidential request and I give consent for my child to take part in the Reading Support for Children Research. I understand that I am free to withdraw my child from the study at any time.

Parent/Guardian's Name Signature

_____ _____

Researcher Signature

_____ _____

Contacts*:* If you would like to ask any further questions about the research then you can contact the principal investigator:

Principal Investigator (S):

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Appendix 2: Spelling Dictation List

1. On
2. And
3. The
4. Up
5. Go
6. Big
7. Sit
8. Bus
9. My
10. Box
11. Was
12. Home
13. Old
14. Do
15. Play
16. Back
17. That
18. Down
19. Eat
20. Come
21. Are
22. Well
23. New
24. Work
25. Bird
26. Walk
27. Boat
28. Soil
29. Morning
30. Eight

Appendix 3: Pictures from Intervention