Mobile Technology Bridges the 30 Million Word Gap

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Abstract
Education has been traditionally viewed as an equalizer for the poor to gain access to a better life. With the advent of the skills premium paired with rapid technological advances, the stratification and changing nature of education has ironically become one of the main causes of the income achievement gap. Research confirms that by the age of 3, children from low-income homes hear 30 million less words than children from more affluent families. Research has even revealed that the gap begins as early as 18 months of age. Children who enter school at higher levels of readiness have higher earnings throughout their lives. They are also healthier and less likely to become involved with the criminal justice system. These positive spillovers suggest that investments in early childhood can benefit society as a whole. Without intervention, the trend will certainly persist and further income inequality will lead to more social instability. Anger and frustration from the lower income classes may result as they continue to struggle with no real hope that it will make a difference to their lives in the long run. This paper traces the causes of the income achievement gap and proposes how mobile technology and the corresponding apps can potentially mitigate these factors by gaining access into the homes of the low income families. Indeed, it is critical to examine the causes of the gaps in order to propose relevant possible solutions. Mobile learning devices now have the potential to achieve a large-scale impact due to their portability, affordability, high memory capacity and ease of use. With the ability to personalize and adapt to the learning needs of the child as well as guide the parent or teacher with scaffolding, tablets can help to fill these damaging gaps and allow each child the chance to learn and succeed.
Keywords: early childhood education, inequality, socioeconomic status (SES), vocabulary acquisition, literacy, mobile apps, tablet computers, word gap, digital divide, income achievement gap

1. Widening Income Inequality Gap

For the past four decades, income disparity has steadily increased in the United States and other wealthy nations. (Reardon, 2013). In the United States a child in the top decile of the income distribution has 14 times as much as a bottom decile child (Corak, 2013). Shockingly, 47 percent of children under 3 years old were found to live in low-income families and 24 percent of children under 3 years old live in families classified as poor (Jiang et al. 2016). Indeed, Corak (2013) forecasts that increasing inequality in the high-income countries, particularly in the United States, is likely to limit economic mobility for the next generation of young adults.

1.1 Skill Premium

With the world rapidly transforming into knowledge-based economies, human capital is becoming more and more important in determining a country's competitiveness (Schwab, 2010). This trend has resulted in a skill premium in which a college graduate in the United States earns about 70 percent more than a high school graduate (Corak, 2013). The International Monetary Fund, Strategy, Policy and Review department published its staff discussion notes, which stated that technological expansion and the resulting rise in the skill premium was the dominant reason for the income inequality in advanced economies with demand focused on skilled labor over low-skilled labor (Dabla-Norris et.al., 2015). An OECD report (2011b) similarly reported that technological changes were the greatest contributing factor to income inequality, accounting for nearly a third of the widening gap between the 90th and the 10th percentile earners over the last 25 years.

1.2 High spending on education

With the goal of having their offspring engage competitively in the knowledge-based economy, parents have become highly sensitized to the need to invest in their children's education and have therefore mobilized increasingly more of their resources of time and money to this end. Kornrich and Furstenberg (2011) used the United States' Consumer Expenditure Survey to examine how spending on children has changed over the period from the early 1970s to the late 2000s. They discovered that spending on education increased substantially during this time. Indeed, high-income families spent approximately 7 times as much on their children's development as low-income families, up from a ratio of 4 times as much in 1972 (Kornrich & Furstenberg, 2013). Parental spending on children is often one of the means by which children from wealthier households are given advantages over children from poorer households (Kornrich & Furstenberg, 2011). Children in families with more resources in the form of human, cultural, and material capital consequently enjoy considerable advantages in their development and long-term prospects (Reardon, 2011).

Kornrich and Furstenberg (2011) find that the shape of parental investment over the course of children's lives has changed as well. Prior to the 1990s, they report that parents invested most in their children's teen years. Since then, they note that spending has been greatest during the preschool years and in the children's mid-twenties. Reardon (2011) identified a cultural shift in the role that parents play in their children's lives. During the twentieth century, parents began focusing increasingly on promoting early-childhood cognitive and psychological development. As Corak (2013) noted, this group has both the resources and incentives to promote the capacities of their children more intensely. Bainbridge et al. (2005) documented that this mindset may be one of the reasons that preschool enrollment grew markedly from the late 1960s to the late 1980s. As the parents of wealthy children have clamored to enroll their children into the best preschools, the price of private preschool programs has skyrocketed. The wealthy willingly pay high premiums for the presumed competitive advantages that will be transferred to their young children. The cost and quality of early childhood programs has therefore become exceedingly stratified. At the same time, financial aid for early education is limited since preschool education has thus far been viewed as enrichment and not part of standard childcare.

Left to these market forces, early education and the care of infants and toddlers has been largely determined by the resources of individual parents. Without a doubt, the huge discrepancies in incomes have therefore resulted in substantial inequalities in the early childhood experiences of wealthy versus disadvantaged children. Bainbridge et al. (2005) analyzed the US census bureau's Current Population Survey (CPS) data from 1968 to 2000 and found a strong link between family income and early education enrollment for three and four-year-olds. Overall, three year old children from low-income families had the lowest rate of enrollment in preschool (Bainbridge, et al., 2005).

1.3 Prestigious University Degrees

Besides heavy investment in preschool education and other so-called value added intellectual activities, the frantic pursuit to do whatever it takes to get your child enrolled in a prestigious college is another symptomatic trend that has dominated the purse strings of high income families in reaction to the skills premium phenomenon. As Corak (2013) described, a selective college degree has increasingly become a gateway to higher incomes; therefore, high-income families actively utilize important connections to help their children gain entrance to these high status schools and even access to particular employers. In 2016, Harvard University had its largest applicant pool in its history with 39,041 students applying for the 2,037 coveted spots that were granted (Harvard Gazette, 2016). Similarly, Stanford University offered admission to 2,063 students from a pool of 43,997 applicants which is also the largest pool in its history (Stanford, 2016). Table 1 shows the historical trend of applicants at Stanford for close to the past decade.

Certainly, the children of high-income families will find it easier to afford college. In the United States, college costs grew much faster than most households' incomes since 2001 (Federal Reserve 2014). Beginning in the 1990s, the price of a degree began rising faster than the cost of other goods and services. Between 2000 and 2013, the average tuition and fees at a four-year public college rose by 87 percent (in 2014 dollars) while the median income for the middle fifth of American households advanced just 24 percent (Schoen, 2015).

2. Widening academic achievement gap

With the high private investment into early childhood education that is being outlaid by the wealthy families, Reardon (2011) infers that it is not rising income inequality per se that has caused the income achievement gap. Reardon's hypothesis is that a real academic head start is being bought by high income families enabling the wealthy to benefit from this competitive advantage from almost the beginning of a child's life. These advantages are then maintained all the way to the university years and even further to future employment.

Before even entering kindergarten, the average cognitive score of children in the highest SES group are 60% above the scores of the lowest SES group (Lee and Burkam, 2002). A given difference in family incomes now corresponds to a 30 to 60 percent larger difference in achievement than it did for children born in the 1970s (Reardon, 2011). In fact, the problem has been well documented for decades. Since the 1950s, multiple studies have confirmed that children from disadvantaged families start kindergarten with lower language and cognitive skills than those from more advantaged families (Bereiter & Englemann, 1966; Golden, et.al. 1969). The estimated income achievement gaps among children born in 2001 are roughly 75 percent larger than the estimated gaps among children born in the early 1940s. The gap appears to have grown steadily since the mid-1970s (Reardon, 2011).

A key goal of education should be to make equally available to every student the training he or she needs to gain the necessary skills to function both in school and in life, irrespective of what skills or knowledge they have accumulated from other sources. But, schools serving low-income students receive far fewer resources, face greater difficulties attracting qualified teachers and receive less support from parents (Lee and Burkam, 2002). Though it is understood that the ideal role for education is that it can serve as an equalizer and increase achievement for all students, regardless of race, income, class, and prior achievement, it is unreasonable to

expect schools to eliminate substantial pre-existing inequalities soon after children first enter the education system, especially if those schools are under-funded and over-challenged (Lee and Burkam 2002).

Researchers have conclusively shown that the inequalities of children's cognitive ability are substantial even before they start school and then these same disadvantaged children are placed in low-resource schools, further exacerbating the initial inequality. Furthermore, children from lower SES families are less likely to come from an environment that promotes school readiness at home and also less likely to be enrolled in educationally-oriented preschool programs outside the home. The disparate access to early education is clearly one contributing factor to the cyclical pattern of inequality in achievement and income (Bainbridge, et. al. 2005).

2.1 Importance of Early Childhood Education

Indeed, there is strong evidence that academic achievement in primary and secondary school depends on the early education children receive (Lee and Burkam, 2002). As Sharon Kagan, a professor of early childhood and family policy at Columbia University describes "The data are really incontrovertible. Three strands of research combine to support the importance of the early years. From neuro-scientific research, we understand the criticality of early brain development; from social science research, we know that high programmes improve children's readiness for school and life; and from econometric research, we know that high quality programs save society significant amounts of money over time. Early childhood contributes to creating the kinds of workforces that are going to be needed in the twenty-first century" (Starting Well, 2012). There is sizeable literature suggesting that, all else held equal, children who have attended preschool enter school more ready to learn (Lee and Burkam, 2002).

In most countries, up until the 1980s, preschool was primarily focused on providing simple child minding (Starting Well, 2012). In a benchmark study of preschool environments in 45 countries, it was discovered that despite a growing awareness of the importance of early childhood education, policymakers still gave most attention to the tertiary, secondary and primary levels of education with the least focus given to the early years of child development (Starting Well, 2012). Education spending, in other words, is allocated to make higher education relatively more of a priority, and in a way that is of relatively more benefit to the relatively advantaged (Corak 2103).

2.2 The 30 Million Word Gap

Of the factors affecting academic performance, vocabulary size appears to be the aspect of language most sensitive to the effects of SES (Rowe et. al. 2013). Results showing that SES differences in verbal abilities are already evident in the preschool years suggest that these disparities must start to develop in the first years of life, setting children on trajectories that have been shown to have long term consequences for academic and financial success in the future (Fernald, Marchman, & Weisleder 2013). A study in 2013 conducted by psychologists at Stanford University showed that a gap in vocabulary and processing efficiency is evident even in toddlers as young as 18 months old. The less advantaged children only reached the same levels of speed and accuracy at 24 months old as compared to the more advantaged children who achieved the same learning at 18 months (Fernald, Marchman, & Weisleder 2013). This 6-month delay in the development of processing efficiency for lower SES children raises serious concerns because research has shown that the disparity persists over time and is predictive of future academic success or failure (Burchinal et al., 2011). By 36 months old, Hart and Risley (1995) estimated that children from low income families heard 30 million less words directed to them than those from higher income families. The significance of this finding was not in the outstanding difference in number of words encountered but rather the corresponding lack of vocabulary acquisition as a result of the reduced exposure at home.

Becker's seminal article in the Harvard Educational Review (1977) noted that early success with decoding was later washed out in higher elementary grades due to limited vocabulary knowledge. The reading comprehension level of the students in Becker's study fell relative to more advantaged students by grade 4 but, their mathematics achievements were sustained. Becker concluded that all the knowledge that is needed for math was taught in school, whereas the vocabulary growth needed for successful reading comprehension depended on input from home. As observed by Hart & Risley (1995) disadvantaged homes provide little support for vocabulary growth. They also reported that the increases in vocabularies which were gained by teaching children new words were temporary. They could easily increase the size of the children's vocabularies but they could not change the developmental trajectory. Whatever new words taught in preschool were lost a year later when the children enrolled in kindergarten. They saw an increasing disparity between the extremes--the fast vocabulary growth of the advantaged children and the slow vocabulary growth of the disadvantaged children. By the time that the children from families with little financial resources made it to high school, they lacked the vocabulary needed to read advanced textbooks and therefore many did not pursue higher learning (Hart & Risley, 1995).

What is even more alarming is that instruction in kindergarten and grade 1 apparently had no impact on vocabulary growth (Biemiller 2001). This finding is particularly significant in view of Cunningham and

Stanovich's (1997) research that showed the clear correlation between vocabulary levels assessed in grade 1 and grade 11 reading comprehension. Those students who had lower mastery of vocabulary in grade 1 were likely to have poorer reading comprehension skills by grade 11. By the end of the second grade, children from the lowest vocabulary group are about 4 years behind the children from the highest group (Biemiller, 2011). Children with smaller vocabularies do not comprehend as well as those whose vocabularies are larger and because they do not comprehend as well, they often choose to read less. The chain effect is that students who read less, acquire smaller vocabularies and comprehend less resulting in a perpetuated gap (Cunnigham and Stanovich, 1997).

3. Current State of Vocabulary Learning
While schools in the United States have become more effective in the primary years at teaching students the mechanics of reading such as phonics and how to identify words, educators have virtually ignored the important task of teaching students to understand words (Biemiller, 2010). Because a large vocabulary is not necessary for reading success during the early primary years, the significance of vocabulary size has often been underestimated. As discussed in the section above, the vocabulary that a child knows is mostly acquired from the home environment, not by what is taught in school. But, in the upper primary grades when reading of texts requires a wide range of words, it then becomes painfully obvious that those children in the lowest quartiles do not have the words in their oral vocabularies to understand third or fourth grade books (Biemiller, 2010). Current education policies and practices have done little to address the national crisis in literacy that is sapping the potential of millions of young children (Guernsey & Levine, 2015). In 2012, the National Assessment of Educational Progress (NAEP), exam showed that only one-third of American fourth graders and barely one in six children from low-income families were reading at the proficient level (National Center for Education Statistics, 2012).

Becker (1977) showed that the cause of children experiencing a decline in reading comprehension as compared to more able peers from age 8 onwards was largely due to a lack of vocabulary knowledge, and that this was primarily caused by a lack of learning opportunities, not a lack of natural ability. Chall et al. (1990) also found that disadvantaged students showed declining reading comprehension because their smaller vocabulary prevented them from understanding the meaning of the texts. A low vocabulary therefore traps children in a vicious circle since children who cannot read more advanced texts miss out on opportunities to extend their vocabulary (Blachowicz & Fisher, 2002). Becker (1977) further identified poor vocabulary knowledge as the primary cause of academic failure of disadvantaged students. The data is conclusive, children with low vocabularies need to be targeted early, since catching up is very difficult. If they enter school behind, they would have to learn words much faster than their peers in order to normalize, at a rate of three to four root words per day over 5 to 6 years (Biemiller, 2010).

3.1 Directed Teaching of Vocabulary
In a comprehensive literature review conducted by the United States' National Reading Panel, it was reported that many studies have shown that direct teaching of vocabulary enhances listening and reading comprehension. Biemiller (2005) has shown through his studies that low vocabulary students are able to learn new word meanings just as well as others do when taught directly, but they learn much less than high vocabulary students when meanings are left to be inferred. He states that expecting students to infer meanings from context has not proven to be effective. Instead, Biemiller (2010) has shown that directly teaching word meanings has led to the acquisition of four hundred to five hundred new word meanings during each primary grade. He further discovered that word meanings are acquired in a predictable sequence, meaning that no matter what age a person learns English, they will learn the same word meanings from a predictable list of two to three thousand words. and therefore, it is critical to learn the word meanings in this sequence because word knowledge and skills are systematically built on earlier skills and word knowledge. If the proper foundation of vocabulary has not been well established, then competencies in reading comprehension will surely be compromised. Whereas average children know about 3,400 root words, low vocabulary children enter pre-kindergarten with around 2,300 root-word meanings (Biemiller, 2005). Without intervention, low vocabulary students gain an average of 570 word meanings per year while average students add 860 meanings and advantaged children add 1,140 word meanings per year (Biemiller, 2010). Because children do not learn every word meaning they are taught, a thousand or more word meaning must be taught each year if individual children are to learn approximately four to five hundred meanings. Biemiller (2010) highlighted the distinguishing factor for teaching vocabulary to preliterate children is that it will mostly be an oral activity rather than a print-based one and will require much direct instruction by teachers.

4. Learning through Mobile Technology
Although directed vocabulary teaching has been shown through research to be conclusively a beneficial approach to mitigating the deficit in word meanings known by low income children, the implementation of such

directed teaching methods requires a tremendous amount of training for parents and caregivers. It is in fact not a natural form of daily conversation for most parents with their children to elaborate on word definitions and it can certainly prove even more challenging to implement for low-income families. Not only does directed vocabulary teaching demand a lot of time and dedication from people who are already strained by other socio-economic factors, it also assumes that word knowledge is sufficient to teach properly. Mobile technology can help address these problems by providing low income parents and children the equivalent of a personal tutor, right in their home, who can supplement the parents and caregivers' speech, offering helpful prompts and accurate dictionary definitions at the swipe of a finger.

4.1 Theoretical framework
Self-determination theory (SDT) proposed by Ryan and Deci (2000) states that human beings are inherently proactive with a strong desire for growth. The precondition for growth is that we seek a feeling of competence, autonomy and relatedness. Ryan and Deci put forth that when these measures are properly addressed, a human being's natural intrinsic motivators are at their optimal state. We propose that pedagogically based games played through mobile technology can help to satisfy these three principles and hence it is suggested that a good mindset is established for learning. Each of the three measures of competence, autonomy and relatedness will be discussed using the context of directed vocabulary teaching through mobile learning in the following sections.

4.1.1 Competence
Research has shown that students should not only repeat vocabulary items often but they should also be given items that engage them with a word several times in different contexts in order to gain competence in the word's meaning. Based on a study conducted by Webb (2007), learners who encountered unknown words ten times in context, were able to achieve sizeable learning gains. However, to develop full knowledge of a word, Webb reported that more than ten repetitions may even be needed. McKeown, Beck, Omanson, and Pople (1985) studied 4th grade students who were tested on tasks of definition knowledge, fluency of access to word meanings, context interpretation and story comprehension. It was shown that high frequency yielded better results on all measures. They found that vocabulary instruction and the frequency of instructional encounters had a strong relation to text comprehension for 4th grade students. Senechal (1997) found that for pre-kindergarten children, repeated readings of a story were associated with greater performance gains in vocabulary. Mobile learning can provide the learner with frequent engagement opportunities in a non-time-intensive way, increasing the learning chances by allowing the user to work on incidental tasks as often as he/she wants for as long or as short as desired (Beaudin et al., 2006). The ability to pick up a tablet for a few minutes of learning while waiting for a bus or while mom is preparing lunch increases the possibilities for exposure tremendously. Moreover, instead of relying solely on the family's resources to mitigate the 30 million word gap problem, mobile learning devices can enter into homes non-intrusively, offering hours of supplemental learning. Mobile apps can also support caregivers and parents about which words to teach and how to elaborate on the meanings for a richer understanding. Accessible with just the swipe of a finger, the meaning of the words can be found by kids and parents alike. With the help of mobile tablets for directed vocabulary teaching, it can be tracked whether a children encounters a word more than ten times, which was recommended by Webb (2007). Instead of repeating boring flashcards over and over, interactive games, stories and songs engage the user in fun activities such that the necessary repeated exposures are achieved sometimes even without the user being actively aware of it. As an interesting and joyful activity, listening, watching, and reading numerous short stories or animations with mobile learning devices was shown to provide substantial learning moments which can lead to competence (Kim, 2009). Gamification is defined as the use of game design elements in non-game activities to make them more enjoyable, motivating or engaging (Deterding, et. al., 2011). The goal in developing the directed vocabulary teaching apps should be to increase motivation and engagement by gamification of the pedagogy. Competence can be described as the opposite of failure. Because learning through games reduces the sense of failure, it therefore also increases the sense of competence. Kim, et.al. (2008) puts forth the notion that one thing is universal in all situations and cultures: learning should be fun, satisfying, and rewarding. For busy parents and caregivers with many matters to manage, it is understandably difficult to keep track of how many times a given word has been taught and it is even harder to keep thinking up innovative ways to make vocabulary learning fun. Mobile apps can track the number of exposures and even space out the repetitions to optimize vocabulary retention while sending a progress report through email to maintain learning accountability and document developing competencies.

4.1.2 Autonomy
Until smartphones and touchscreen tablets were introduced, it was difficult for young children to interact meaningfully with technology. Keyboard-based computers required fine motor and cognitive skills that very young children have not yet acquired. Heller, Sturner, Funk, and Feezor (1993) examined the issue of cognitive demands of technology for preschool learners, by studying the effect of different input devices (touch screen vs. keyboard) on vocabulary identification. They concluded that the greater cognitive demands of keyboard use

disrupted the children's ability to perform at his/her highest level. In contrast, multitouch screens have been shown to be intuitive and require little or no instruction even for young toddlers. Studies indicate that children as young as 2 years old can easily interact with touchscreen technology (Chiong & Shuler 2010). Tablets therefore give children more control over their computer experience and therefore enable them to gain a sense of autonomy. Mobile apps allow very young children a whole new way to interact with images, sounds, and ideas.

4.1.3 Relatedness

The range and potential effectiveness of technology use for young children cannot be fully realized simply by placing Internet-connected devices in early childhood settings (Daugherty, et. al. 2014). An important emphasis must be placed on the principle that learning through mobile technology is not intended to replace interaction with parents and caregivers. Too many times we have all seen tablets in the hands of children being used as a pseudo babysitter. Rather, if used properly, we envision that mobile learning can improve and facilitate better engagement between adult and child, fulfilling the third criteria of SDT, which is relatedness. With the help of mobile learning devices, parents are more effectively equipped to help their children develop the knowledge, skills, and abilities necessary to reap the full benefits of technology as a tool for learning and growth. The theory of scaffolding, or the support which a teacher, parent or expert provides a child or novice, means that learning and cognitive development are facilitated beyond what the individual can currently achieve on their own. When parents and caregivers employ mobile technology in this way, it will generate the right mindset for intrinsic motivation to prevail. To date, educational mobile apps have not taken full advantage of the opportunity to provide scaffolding tips to parents and teachers. More can be done to improve apps so that they can offer scaffolding help through audio prompts or word balloons that parents and teachers could then piggyback upon and reinforce.

4.2 Digital Divide

Besides the proposed benefits to literacy attainment, mobile technology can also help to correspondingly bridge the digital divide. Many children in low-income families are not able to access and use technology in the same ways as their more advantaged peers. A research report produced by the Rand Corporation (Daugherty et. al. 2014) asserts that technology literacy plays an important role in a child's ability to succeed in school and later life. While disadvantaged youth may use the Internet more often than their more-advantaged peers, they are less likely to use it for educational purposes and largely use it for entertainment and social networking (V. J. Rideout, et. al., 2010). Another study reports that 75 percent of higher-income parents have downloaded educational applications for their child, whereas only 35 percent of lower-income parents have done so (Warschauer & Matuchniak 2010). If learning is encouraged through mobile technology from a young age for low-income children, the self –determination theory supports that the child will experience intrinsic motivation for growth and independently seek out learning opportunities. When students are engaged in the tasks in which they were learning vocabulary, they had larger gains (Senechal, 1997). Couse and Chen (2010) conclude in their study that the tablet computer appears to be a viable tool for use with preschool children. They assert that tablets can prepare children to be digital citizens who are technologically literate.

5. Future Research and Proposals

In 2016, the Apple App Store had over 80,000 apps categorized as educational. Although apps are labeled as educational, they are not held to any standards or subject to any certification (Hirsch-Pasek, et.al 2015). Most of the apps on the market are developed by programmers and not educators (Shing & Yuan, 2016). In April 2012, Guernsey & Levine (2015) took a snapshot of the app marketplace and they discovered that among the most popular paid literacy apps, 45% targeted letters and sounds and half targeted phonics, but only 5% targeted vocabulary. None of the iTunes paid apps focused on comprehension, grammar and the ability to understand and tell stories, which are all critical to early reading competencies. As already discussed above, research has confirmed that knowing the ABCs and other basic literacy skills, while important, are not enough to help children become strong readers. Children need background knowledge and vocabulary (Guernsey & Levine, 2015, Biemiller, 2010). Apps produced or designed by educators have the potential to translate decades of research and experience into a mobile learning platform that could be distributed directly to those who need it most (Shing & Yuan, 2016). Based on the literature reviewed in this paper, we would like to propose some recommendations to educators in the literacy field to consider for creating more effective mobile learning apps to target the 30 million word gap issue and close the income achievement gap. We recommend that early childhood vocabulary apps should:

1) teach word meanings based on the order of the naturally occurring sequence which Biemiller (2010) referenced in his research;
2) include extended definitions which can be easily accessed by students and parents;
3) offer scaffolding pop-up prompts to aid teachers and parents with what to say in enforcing the word meanings which will especially help pre-literate children;

4)   repeat vocabulary words more than 10 times in a variety of different contexts, using different media such as video, audio and textual exposure;

5)   utilize gamification methods to engage students while being very careful to adhere to pedagogical learning principles and avoiding distractors;

6)   assess initial competencies and adapt the teaching to match the learning level of the individual user;

7)   personalize the user interface as much as possible to help the emotional connection and reduce the anxiety over performance;

8)   enable automated tracking of learning progress and word meaning exposure which can be disseminated by email;

9)   create colorful and fun graphic content which actively engages the learner;

10)   develop a series of apps which reinforce each other while introducing new content to keep learning fresh and interesting as opposed to boring and repetitive.

Proposed future research would be to investigate the effectiveness of apps which have been developed by academics in the area of early childhood literacy and using the findings to suggest improvements for the next version of these apps in a continuous design based research process. Indeed, the problems presented in this paper cross several different areas of academic knowledge. Hence, researchers in the fields of vocabulary acquisition, sociology, psychology, linguistics, second language acquisition, education and management of technology can explore interdisciplinary research to explore how their existing research and potential new research can help to build a more multidimensional solution employing mobile technology to address the literacy gap and consequently the income achievement gap.

Furthermore, Joseph and Uther (2006) point out that there is no formal theory of mobile language learning developed to date. Mobile technologies have nonetheless increasingly demonstrated the potential to offer language learning solutions which are highly interactive, ubiquitous, and convenient (Joseph and Uther, 2006). Given that mobile technology has only entered the market in the last decade, its full potential has still not been well explored. More research focused on specifically this nascent area will be necessary. It will certainly benefit the academic community overall if a formal theory of mobile language learning were to be established.

6. Conclusion

The income achievement gap problem is well documented and has persisted over the past 40 years or more. The impact to society is significant as the cycle of poverty sadly continues from generation to generation. Education through schools was previously the way in which inequalities in skills could be addressed. Given the skills premium phenomenon and the astronomical investment by wealthy parents into their children's education, the low income children have been squeezed out of contention for a place in society's echelons even before the starting line. With 47% of children under three years old living in low income families in the United States, the odds are stacked against these children from the start of their lives. The problem is clearly outlined in literature but, the question that blares out is how to close this gap? In this paper, we have concurred with the findings that the 30 million word gap is one of the leading causes of the academic achievement deficit in learning before school starts. We also highlight the difficulty of addressing this word gap given that the primary caregiver and schools in low income settings are already resource taxed. We propose that educational apps played on tablets can support and enable developmentally advantageous speech and directed vocabulary teaching. Learning through mobile technology satisfies the three measures of the self-determination theory and therefore results in a conducive learning condition which in turn can help to mitigate the word gap problem and consequently the income achievement gap. Mobile technology offers a solution, not to replace the caregivers and teachers, but rather to increase and facilitate better interaction. Ironically, technological advancements may have been the impetus for fueling the skills premium, which cemented the income achievement gap for so many years, but we propose that technology, and specifically mobile technology, may be a key part of the solution that can substantively address this longstanding and detrimental cycle. More work needs to be done before mobile technology can truly help to deliver the learning outcomes that are needed, but the potential is certainly real and serious effort should be given to developing this vibrant learning platform.

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