Learning through Play: Designing a Game-Based Curriculum to Teach Numeracy Skills

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Abstract
Numeracy is increasingly being considered as an essential and invaluable tool in an individual's daily life, and determines their interactions with the world around them, whether financially, socially, or professionally. This has spawned several educational initiatives that aim to introduce numeracy to young schoolchildren in an effective manner. However, these are either found to be inaccessible to visually impaired students without modification, or use high-end, expensive technology, that are not easily found in schools for students who are visually impaired. This poster describes an ongoing study that aims to create a curriculum for teaching numeracy to students who are visually impaired through card games, which are accessible, easily available, as well as fun to play.

Keywords
Play-based learning; STEM education; students with visual impairments; ludic design framework for accessibility

Background
Numeracy is increasingly being considered as an essential and invaluable tool in an individual's daily life, and determines their interactions with the world around them, whether financially, socially, or professionally. Improving numeracy for students is considered important based on its correlations with the quality of their decision processes and outcomes (Peters, Västfjäll, Slovic, Mertz, Mazzocco, & Dickert, 2006; S, Cokely, & Garcia-Retamero, 2014).
However, technical subjects such as Science, Technology, Engineering and Mathematics (STEM) have often been cited as difficult for blind or partially sighted students and their achievements in Mathematics often tend to be below their performance in other academic subjects (Dunkerton, 1997; Beal & Shaw, 2008; Cryer, 2013). Despite this supposed difficulty, there is evidence that blind and partially sighted learners can perform well in STEM subjects. Blind scientists and mathematicians like Abraham Nemeth, Bernard Morin, Newell Perry, Lev Pontryagin, and Nicholas Saunderson demonstrate that vision is by no means a prerequisite for extraordinary achievement in these disciplines (Amalric, Denghien, & Dehaene, 2018). In fact, researchers have maintained that this observed gap is likely the result of sub-optimal opportunities—including technological resources, learning activities, and instructional methodology—for teaching and communicating about mathematics and spatial concepts using common non-visual accommodations (de Freitas, 2016).

The broader objective of the research is to recognize the needs of students with visual impairment to adopt the ACM India Computational Thinking curriculum in schools. In order to achieve this objective, it is imperative that VI teachers and students have adequate numeracy skills to act as foundational requirements to acquire CT skills. This research study, undertaken jointly by Microsoft Research and Vision Empower, aims to develop a full-fledged curriculum for inculcating numeracy skills in students who are visually impaired, through play. One of the interventions being explored in schools for visually impaired uses playing cards as a means to develop foundational numeracy skills. This hypothesis arises from the qualitative inputs from a sample of STEM experts that card games offer an inexpensive, easily affordable, and interesting way of learning numeracy concepts and attitudes towards future learning of Mathematics. The following sections detail the objectives, theoretical framework, methodology, and preliminary findings of the study.

Objectives

The following are the objectives of the study:

1.To develop a curriculum for teaching concepts of numeracy through play in a classroom of sensory diverse learners.2. To understand the modifications and accommodations necessary for young visually impaired children at various levels of comprehension to play cards.

Theoretical Framework

The study is based on the Ludic Design for Accessibility (LDA) methodology (Swaminathan & Pal, 2018), which emphasizes play as an integral part of the learning process, even an integral part of our lives (Huizinga, 1950). Learning through the process of play forms the basic framework underpinning the study. Play forms an important foundation for the development of skills in all children. Unfortunately, for infants and children with disabilities, real play may be absent or diminished due to accessibility concerns. It has been pointed out that children with disabilities have a higher chance of being left out of play while they grow up, which may have serious implications on the cognitive development of the children (Swaminathan & Pal, 2018).

Methodology

The primary research for this study has drawn upon existing scholarship on the pedagogy of Mathematics for school (K-12) going children, literature on games as a means of introducing children to Mathematics and on some existing publications on making Mathematics accessible to the visually impaired community. The ongoing secondary research is being carried out at three residential schools for students with visual impairments located across Bangalore. The fieldwork commenced in the 3rd week of June. The games are played in one of the Games periods in the school time-table. Each school has 1 session per week. The sample includes around 10-12 children from each school and consists of children from diverse backgrounds, ages and level of visual impairments. Children in grades 2, 3 and 4 have been selected for the study. The study is qualitative in nature. Data is collected in the form of observation sheets filled out by each facilitator after each session.

Preliminary Findings

The Need for Different Levels of Playing Cards

The study underscored the need to have different levels of playing cards for the children to use. The off-the-shelf braille playing cards are designed with 2 characters on the upper right corner: the first indicating the number and the second indicating the suite. The absence of braille number indicator or a capital letter indicator confused the children. Moreover, the 4 suites were as of yet abstract concepts to children who had never known what spades, diamonds, hearts and clubs look like. Therefore, a new set of cards was deemed necessary for beginners: this set was designed with a number on the top left corner, the tactile representation of the suite below it, and a dotted representation of the number such that children who do not know braille can count the number of dots. Once the children are familiar with the suites, off-the-shelf cards can be given to them with an explanation that the second character indicates the suites they had already felt on the previous pack.

The necessity of Making Different Groups

It was found that even at the same age, different children absorb information and engage in the game at different levels. Therefore, it was necessary to separate the children into different groups so that play is both interesting enough to keep the fast learners engaged as well as provided a thorough grasp of the basics to the others.

Games that Build up from the Basics

The games have to be designed in such a way that they build children's numeracy skills up from the basics, rather like having different levels in virtual gaming. How fast children proceed through the games depends on their age, level of prior exposure to cards, level of braille reading, and the duration of enrollment in the schools. The games that were played and the numeracy concepts they teach have been detailed in the following table.

Games	Numeracy Concepts
Counting cards	Counting, associating numbers with objects
Distributing a certain number of cards to others	Counting, addition, and subtraction the concept of total, comparison of numbers (more, less and same)
Gathering all cards of a certain suit	Number recognition, pattern identification, skip numbers, sorting
Go fish	Number recognition, concept of equal
Biggest and smallest number possible out of a set of 3 cards	Comparison of numbers, place value
Raise to 27	Addition, logic, drawing a card from the deck
Last man standing	Place value and face value
Sequence	Pattern recognition, sequencing

Table 1: Games played with the children and numeracy skills they inculcate.

Dealing and Drawing

Cards are now dealt directly into a child's hands rather than in front of them for ease of location. A drawing deck has to be placed in the center so that cards do not get knocked down accidentally. The deck can have 2 compartments: one for the drawing deck and one for the playing deck. The children can also easily check the cards their friends have put down.

Collaborative Play

The card games promoted student collaboration and engagement in a play-based learning environment. The students constantly taught each other how to play, introduced rules to children who were absent in the previous session, and helped others with their cards wherever they deemed it necessary. Therefore, certain collaborative games rather than competitive games also became popular among players.

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