

Voice Gesture Framework in Digital Interactive Storybook for Hearing-impaired Pre-schooler.

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Abstract: Listening and talking are challenging to preschools with congenital hearing impairment assisted with hearing aid or cochlear implants. They need more scaffolds in their learning as compared to normal hearing children and their parents need more guidance in their teaching. Most existed digital storybook does not incorporate learning scaffolds and many do not study the interactions guiding the use of multimedia in this context. Voice gesture framework, a design approach, is proposed to guide the design of interactive storybook for hearing-impaired children. The exchange of voices between children and computer becomes the motivating and assessing interactions for vocabulary learning within a story. Using the benefits of portable digital touch screen device, we incorporate learning scaffolds and interaction design patterns into the storyline, so the book can guide children to talk and listen with/without accompanying parents. The process of encouraging preschoolers to read and speak within the interactive storybook is shared in this paper. We hope this framework would inspire more related works in this area and serve as a starting point for discussions in interaction for interactive storybook designed for these children.

Key words: *Special need learning, Hearing impaired children, child-computer interaction, interactive storybook, interaction design*

1. Introduction

The interactivity of media interfaces such, as mobile applications have to be designed mindfully to improve the user's quality of life. In the field of human-computer interaction (HCI), researchers study how applications can be better designed for users by observing patterns within experiments or drawing guidelines from successful applications. Interactive tools have always attracted the attention of designers as well as scholars. However, the definition of 'better' varies widely in different scenarios and when different users are involved. Guidelines such as visibility, accessibility, legibility and language in a user-centered design (UCD) are good for interactive media used by expert users who want to use it to assist them. For learning students, learner-centered design (LCD) will be more helpful [22]. Instead of assisting students in what they are doing, application imparts knowledge to guide them in a new and unfamiliar activity. These guides are sufficient for their intended aims as user-friendly or supportive learning applications for specific group of learners. However, they are often overarching theory that may not be informative enough to be implemented on applications for children with special learning needs [29]. Without extensive experience or the knowledge in this specific area, designers may have difficulties to incorporate the additional learning needs within the learning application. Hence, to guide designers who are interested to build interactive storybook for hearing-impaired children, there should be a framework that consists experience and insights from experts and parents to highlight the needs with the learning scaffolds for better learning.

This paper discusses instructional and guided interactions for better learning within storybook reading for children born with congenital hearing impairment and are assisted with hearing aid or cochlear implants. These hearing assisted children (HAC) who since birth listen through these devices have different sound perception from children born with normal hearing due to the lacking sound quality provided by the hearing device. Devices that are available to assist in hearing acts as acoustic filters to control what children can hear (i.e. the carol flexer). The acoustic filter effect as illustrated by Flexer, “is analogues to having a malfunctioning computer keyboard that interferes with data entry to the brain”[6]. Their perception of spoken language is different from normal hearing children and additional attentions are required to ensure effects from these devices do not affect their language development.

Differences between HAC and hearing children’s language-learning situation drive the need of this framework. Mayers and Wells [13] claimed four conditions that the language-learning situation have to be present for a learner to be literate. They are 1. the adequate exposure in quality and quantity, 2. to be accessible to linguistic input, 3. engaged in meaningful interactions, 4. with others who are already capable users of the language. For most hearing children, they can be generally assumed to have sufficient exposure to the language in quality and in quantity [13]. When provided with these conditions, language acquisition can occur effortlessly [14]. Although there may be a variation in the quality, they still have access to the language input visually and audibly. HAC on the contrary have problems meeting these factors as compared to children who can hear [14]. Their disadvantage to language development can lead to bigger problems because language is the tool that one uses to “plan, narrate, make queries and even reflect on, and analytically examine speech itself”[19].

Considering the variance in all factors characterizing the language proficiency of HAC, they may still achieve better reading competencies compared with their hearing peers with better scaffolds in learning and listening environment [8, 20]. Scaffolding, simply a structure or support, can be defined as the process that enables learners in solving problems that is beyond the capability of the learner [30]. Scaffolds play important roles in supporting HAC learning [28] and are researched in the field of auditory verbal therapy (AVT) and related. These scaffolds can be embedded in applications to support learners in areas that they might find it challenging [21]. Applications can be developed with these scaffolding features to avoid those possible breakdowns in learning. Although support from an application is differ from provided by parents or teachers, it might be a good starting point or supporting platform for parents who do not feel sufficiently adequate to teach their HAC how to read [20]. Above all, parents’ provision in reading affects language skills of HAC [7, 28]. With 95% of deaf or deaf and hard-of-hearing children born to hearing parents [17], a guided platform for parents to use could be a better option.

2. Design and Development of the Framework

2.1 Motivation for Framework

There are three different factors that motivated this framework. 1. the existing content of the storybook could not help them to compensate the content missed out from incidental hearing. Most of the studies used award-winning or well-received books with content catered for normal hearing children who can learn incidentally from their surroundings. 2. the storybook does not incorporate learning scaffolds. Previous studies with HAC compared between digital and print books but did not redesign the digital book to incorporate the scaffold within the storybook. Instead, the scaffolds are taught to parents through video or guided with cue cards [7, 18]. 3. there are

no existing guidelines for interactions within the interactive storybook tailored for HAC. Although it is understandable that interlacing learning scaffold within digital interactive speech recognition enabled storybook for HAC is new, there are studies on speech recognition enabled storybook/game uses interaction similar to our study. However, they are designed for children with other special learning needs. For example, Say-N-Play is a commercially available desktop game for children with difficulty in articulation [10]. It encourages children to articulate words correctly in order to advance in the game. On the other hand, Project LISTEN is a research study which designed a digital reading book for children with low literacy and who are trying to learn English as their second language in developing countries [16]. These storybooks/games are noteworthy but could not be adapted for our scenario.

2.2 Main Focus of the Study

It is hypothesised that the use of a digital medium in an informed approach consisting of the learning scaffold and interactive media features can aid language development among HAC. This voice gestures framework will be useful for designers to develop digital interactive storybooks for HAC and their parents. It encompasses scaffolding techniques from AVT and experience from interacting with HAC and their parents to instill the knowledge for informed design. These features are useful to support learning among HAC in their language development.

2.3 Platform for Learning

We made use of interactive storybooks to weave the scaffolds within a story for supported learning. The rapid expansion of interactive storybooks made possible on portable digital platform such as touch screen tablets made content delivery convenience and create more opportunities for usage. This platform is also chosen because of additional benefits. Research has found that reading digital books compared with the print version leads to more discussions that would enhance children's development of languages [1]. Other studies also mentioned that digital storybooks, when read together with parents, provided greater levels of language acquisition support to children [11, 18]. The availability of interactive content through portable devices changed the way young children interact with storybooks and experience reading. In addition to print storybook, children now have selections such as oral rendition and repeat as often as they wish. The options of animation, video, music, sounds effects, motions act as the mediators between the child and the story. They can help to retain the attention of the child and a filler to bridge the gap between children understanding the meaning of some text [15]. Given the diversity of enriched visual illustrations and enhanced audio features digital storybooks are capable of presenting, they are especially beneficial for children with lower proficiency of language [24].

The benefits of reading and what it can offer are recognized since the 1980s [26]. A storybook in print version has always been an enriching platform for preschoolers to develop their language together with their parent. For HAC, it provided them with greater exposure to wider variety of words and skills that can be taught directly [6]. This exposure is especially beneficial to them as they can hardly acquire skills and language through incidental learning. Most hearing devices' sound quality diminish over distance and make incidental learning for HAC difficult. The storybook provides the basic grasp of words and helps inculcate developmental skills that may rarely occur in a normal conversation or other language situations [2, 4, 25]. With frequent shared reading, the increased exposure to a larger collection of vocabularies [23] will make HAC better readers and develop predictably good comprehension skill [2, 28]. It supports their phonological awareness, ability to understand and

manipulate speech sounds, which is a strong predictor for success in reading at later stages of language development for HAC [9, 19].

2.3 Learning Scaffold and Design Patterns

The framework is crafted not to limit the creativity of designers; instead, it attempts to provide the structure within the storybook. The learning scaffold embedded in the storybook is portrayed as the frame to transfer the key language concepts, vocabulary and word's sound to HAC while the speech recognition technology is used as the assessment component. The scaffold embedded can be discussed as the three rings around the content to be taught. The rings described as Exposure, experience and expression are stages of how children learn the meaning and sound of a word, and are similar to pedagogical cycle of "teaching, game play and practice". The content to be taught in the storybook is drawn in the center of the framework so the scaffolds are used to bring out the meaning and sound of the word. The three different rings derived from the understanding of how HAC learn. The structure within the storybook allows designers to fill the gap with their creativities. The scaffold is like an instruction to build the frame but not how the designers want to construct the story.

The interactions in this framework are condensed into patterns but not guidelines such as gestalt principle that guides budding designers in understanding theory behind good design. Rather than having guidelines to inform designers how to construct the interactions, we craft it as patterns where designers can use it flexibility as seen in the field of architecture, interaction design and in object oriented programming. Guidelines are wonderful tools and the principle forms the basis for graphic and users interface design. However, designers work by finding novel way to do things in each scenario [12]. Design patterns are conventions derived from repeatedly occurring problems and used to document interaction possible in different stages of the scaffolds [22]. For interactive storybook designed with our framework, we like to see the language learning process framed and designed differently in each story to maintain the 'freshness' of such applications. Patterns provide the required flexibility but also make the characteristic within the set of interactions explicit. Designers should be able to propose myriad of ways to show the meaning of word or form the definition of an interaction creatively. The use of this framework should not be a 'clone'-making machine. Instead, the scaffolds proposed show how the knowledge can be conveyed in each stages of learning through an informed manner. The combination interactions within should be up to the discretion of the designers with the help of patterns.

Voice gesture framework draws the learning stages as rings and the interaction patterns as bubbles. The concept of 'voice gesture' is derived from the assessment component built within the learning scaffold. Children or parents have to say the target word to proceed to different parts of the storybook. The step for HAC to read out the word is important. As the child read out the word, parents or caregivers can validate if they are listening correctly. If the 'malfunctioning computer keyboard' input an incorrect data into their brain, it is unlikely that they will use the correct data in speech. Parents can then assist HAC to better their listening and speech. As Flexer mentioned that reading the word aloud should not be the sole aim of the activity, hence, it is important to wrap the voice gestures with other interactions like these proposed in the framework [6].

3. Design Process of Framework

Since existed literature offers few or no references on how to design scaffold and patterns for HAC's interactive storybook, research have to be gathered from stakeholders of these storybooks. In this study, we

collected rich data from stakeholders – 2 therapists, 9 parents, 8 HAC, 6 normal hearing children and 2 preschool teachers to develop this framework. It is the result of a user centered design process. It went through the three stages of analysis, design and evaluation as shown in Table 1. In this study, the team and stakeholders contributed at different stages of the design process from their expert point of view. Their insights are then tuned and made in focus on the interactions and the learning scaffolds that designers will be interested in.

Table 1. Design process of framework with elaboration

First Cycle (Initial Concept)		
Analysis		<ul style="list-style-type: none"> Explore the possibilities of using speech recognition technology embedded within storybook Investigate the strength of motivation for HAC to use this system
Design	Observe therapy sessions and conduct home visits	<ul style="list-style-type: none"> Explore/observe cues used to entice HAC to say the word Craft the rewarding mechanism
Evaluation	Play with HAC	<ul style="list-style-type: none"> Take existed story to incorporate cues and rewarding mechanism for validation
Second Cycle (Refinement: Concept + content)		
Analysis	Discussion with therapists	<ul style="list-style-type: none"> Explore the content construction process of the storybook Dissect the learning phase
Design	Literature reviews	<ul style="list-style-type: none"> Categorise cues, rewarding mechanism and other interactions into design patterns Design first version of the storybook
Evaluation	Play with HAC and hearing children	<ul style="list-style-type: none"> Validate storybook with children and pre-school teachers
Third Cycle (Final Concept)		
Analysis	Discussion with pre-school teachers	<ul style="list-style-type: none"> Allocate design patterns into different stages of learning
Design		<ul style="list-style-type: none"> -Explore the combinations of the patterns within the scaffold
Evaluation	Play with HAC and their parents	<ul style="list-style-type: none"> -Validate use of storybook over a period of time

3.1 Interface Requirement – Cue for Speech

Talking is the assessment element tracked and a reflection of the progress of HAC. The cue embedded within the interactive storybook has to direct the child or the accompanying parents to say the word. The cue has to be clear in signaling the action of saying the word so the child can learn to respond to the cue and be motivated to say the word to get the reward. In this study, extra effort is taken to understand how the interface cues should act to acquire such feedback. In the first cycle of our iteration, we used existing materials from child's auditory verbal therapy and embedded different cues to entice the child to say the word. These techniques range from one that is commonly used by teachers or parents to one that is new. Old techniques include circling the words, highlighting the word and related. New techniques, such as colour changing words and animated words (jumping words for the word 'jump'), are introduced in hope to find new ways that are conventionally not used in paper medium.

The test is conducted with HAC and the process was voice recorded for review. Interviews with parents and therapists were conducted to better understand the result. Even though we have limited sample size in this study, there are several interesting findings. Reward cues are generally better motivators as compared to conventional cues and action cues.

Table 2. Categories of cues with elaboration

Cues categories	Elaboration
Conventional cues	<ul style="list-style-type: none"> • Circle the word to be said • Placing the word under object • Highlighting the word
Action cues	<ul style="list-style-type: none"> • Animating the word like the meaning of the word
Reward cues	<ul style="list-style-type: none"> • Highlighting the word and when the word is being said, the animation is being triggered.

3.2 The 3E's

HAC have a disadvantage with their listening and tend to use sight than their hearing. When parents introduce new objects in their learning, therapists advise technique such as “listen, listen, and then present visual cue” method which gets the child to listen before responding rather than watch and respond. For an example, parent can say “look, that is a red car. Did you see a red car?” After gathering child’s attention and anticipation on the sound of red car, parent points at the car to bridge the connection between what she said with the visual cue.

Breaking down the process of learning to the stage of using the word, HAC will goes through 3 stages: Exposure, experience and expression. To learn the word ‘cold’, HAC first has to expose to the word sound by listening to the word and experience the meaning of the word by touching something cold. When they acquire both sound and meaning of the word, he/she should be presented the context for them to express the word to check if they listened and understand correctly. Similar to the learning cycle of hearing children, the first stage involves teaching where children are exposed to the word. The second stage allows them to experience through game play and the last stage of practice to let them be familiarized with the word. The 3 stages are similar to normal learning phrase of a hearing children but it places more focus on listening and use of the word by saying the word. The focus on listening and talking for the scaffold is to help compensate the acoustic filter effect from their hearing devices. The relationship of listening and talking with the learning progress is illustrated with the graph below. The likeliness for a child to say a word is lowest at the stage when he/she is first exposed to the word and gradually decreases with more exposure. Listening on the other hand is less likely to be the sole activity when a child has already learnt how to use and say the word. The understanding of what is happening at each stage is important for designers who are deciding what design patterns should appear in the interactive storybook.

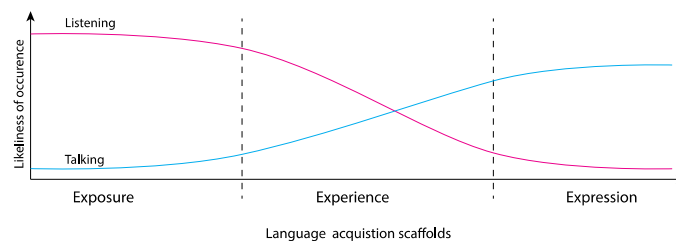


Figure.1 Visual representation of language learning stages against likeliness of occurrence for listening and talking

The patterns within the scaffolds will be guiding HAC and parents and have to be neatly crafted to provide enough support for better language acquisition. Same as Fung et al [7], the scaffolds they prepared for parents to provide dialogic reading are available on every page of the storybook. On every page, five questions were

prepared based on the prompts designed by Whitehurst et al. [27]. Not only questions were prepared, the team has to demonstrate the techniques with guidelines and checklist. A considerable amount of effort is required for parents to learn the scaffolding activities required for better learning and for the team designing the activities.

The framework will be explained in sequence of the language acquisition scaffolds. Within each ring, description and purpose will be elaborated. A table following the description is added to provide examples for the elements in each ring. Finally, the creation of an interactive storybook is discussed in relation with the framework.

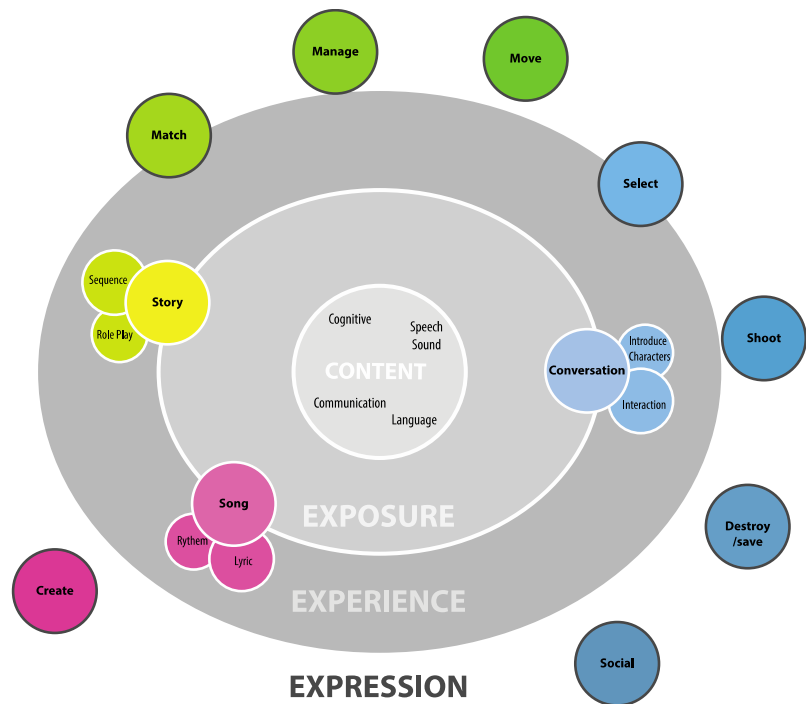


Figure.2. Voice gesture framework

3.3 Exposure

The first ring of the voice gesture framework is exposure. The main purpose of this ring is to ask designers to reveal the word to be learnt to the HAC and their parents. There are many ways the word can be introduced to the HAC. From the experience of designing the prototypes, it requires some knowledge to select the type of interaction that is optimal to illustrate/describe the meaning of the word. In the construction of the storybook discussed in this paper, therapists and preschoolers’ teachers were involved to provide insights for the chosen activities and participate in process of selection. Understanding that experts may not always be present in this stage, designers can choose one of three areas (storytelling, conversation and song) based on descriptions provided in the table below. The description under each category defines the parameter designers can work on and the type of exposure they can define with the meaning of the word.

The adventure of the shark and friends is the interactive storybook that we created with framework. In this version, words such as behind, under and above are taught. These are words that require the interactions of more than 1 objects. Hence, storytelling is used to demonstrate the action of the words and not with song or conversation. In this story, Shark and his friends are the characters to illustrate the relation of the words with other objects in the designed context.

Table 3. Elements in rings of Exposure and Experience with elaborated with examples.

	Storytelling	Conversation	Song
Exposure	For content where the character brings children into different context for word exposure or when there is a need for action or sequence, e.g. for words like before, after, or dance and sing where a character has to illustrate the action.	For content that needs interaction between 2 or more objects/character to illustrate word concepts, e.g. preposition and actions like catching, hugging	For content that do not need interaction, actions or the context of the words is easily available, e.g. body parts and colour of rainbow.
Experience	Sequence – Introduce the start and end of the story. Role play – Describe the story with reader as the main character	Introduce characters – Introduce the characters/objects and the roles they are playing in the context Interaction - Present the interactions between the character with the context, object and characters.	Rhythm – Introduce the ground for which the words will be learnt Lyric – Present the lyric to bridge the sound of the words with visual representation of the sound.

3.4 Experience

After choosing the category within the first ring, the framework will lead designers into the next set of activities linked with the bubble in the second ring. In this stage, the story should support HAC in experiencing the meaning of the word. The bubbles in this ring provide the necessary elements required for the chosen activity in first ring. The exposure ring introduces 2 basal interactions that should not be missing from the chosen category. In this story, the reading child is the ‘shark’ and the start of the story begins with the shark counting from one to five. The sequence was introduced from the start of the story with the game ‘hide-and-seek’. The ‘shark’ had to look for one after another of his friends who are hiding behind different artifacts in the sea. It helps prepare the child of what to look for and what to do at different phase of the story. After Shark and his friends were introduced, the relationship of the words with other objects is then presented.

3.4 Expression

In relation to the learning cycle, the expression ring made use of game actions theory to build the ‘game play’ into learning. It is the stage where HAC make use of what they have learnt to gain confidence to use the words and a ground to put themselves in challenges to better what they learnt. The bubbles within the ring of expression are inspired from gameplay bricks from Djaouti et al [5]. They proposed a classification method that is based on the recurring game rules of more than 580 games. The classification is ideal for our interactive storybook because we need a set of guidelines for the type of game play to be incorporate into learning without restricting the play to only a few type of game. Previously, we explored numerous interactions possible for this stage. However, we realized that the act of proposing specific game plays would limit the other possibilities for other play and the flexibility for application. With the game action bricks, the framework is able to generalize different game plays into categories that designer can use to practice words with HAC. They are suggestive constructs that provide specific rules but not the type of play, for example, the action of ‘Destroy and save’ can be used in Apace Invader to destroy aliens and also be used in Bubble Bobble to remove the bubbles crashing down to the dinosaur. Differing from the set of bricks proposed by Djaouti, the random brick is removed from the framework. Randomness helps to motivate children to guess and try within the story and is very hard to justify if the child understood the word or not. Introducing the option of random bricks into the framework might confuse children

what is right or wrong and make record keeping difficult. The chosen elements for this framework are elaborated in the table below. It explains the activity behind each bubble and provides a possible activity.

Table 4. Elements in ring of Expression with elaborated with examples.

Create	Match
Express creativity through the act of assembling, building or creating elements, e.g. Building a house with objects that were learnt or colouring the objects with colors learnt from rainbow song	Replicating the action, word or like in the context created. e.g. Saying “dance” when the character is dancing or move the character right when the story said it is going right.
Manage	Move
Doing an action to maintain the equilibrium within the story, e.g. Saying “fish” to catch the fish within the story to feed the main character.	Doing an action to reach the goal within the story, e.g. Saying “left” or “right” to avoid being caught by the character that will end the game or similar.
Select	Shoot
Choosing the correct options to proceed, e.g. Saying right verb such as run, crawl or walk to catch the bear moving away from user	Choosing options but the outcome is random, e.g. Saying action words such as shoot to fire the net to catch fish, but fish might be caught or not.
Destroy and Save	Social
Removing obstacles within story to assist character, e.g. Saying words to stop the invading aliens from attacking earth	Having a platform to showcase performance, e.g. The found treasures are displayed in a shelf to motivate others to find the treasures.

The positions of these bubbles on the experience ring or in the experience ring are dependent on the properties of their game action. Bubbles such as Select and Match are simple activities that can be used either as an experience activity or an expression activity. For Select and Match, the activities only requires child to listen, understand then respond. The level of difficulty is not as high as Move or Destroy where child has to listen, understand, plan, understand the result of action, and respond for the next step. In this framework, the further the bubble is away from the experience ring, the more scaffold is required for a child to get it done correctly. The distance is used to remind designers that more learning time or storyline is required before a child can accomplished the task.

For *The Adventure of the Shark and Friends*, ‘Match’ and ‘move’ were used to construct the storyline. For ‘Match’, the child has to say word of the action. For an example, child or accompanying parents has to say “under” when the character is under the shoes. The idea of matching is similar to the idea of having picture cards with word under the image. With our framework, children are first exposed to the sound of the words then to the words and the visual representation of the meaning of the word. For ‘move’, child or accompanying parents has to do an action to reach the goal within the story. In the story, child has to move the shark to the correct position after listening to the instruction. Child has to move the shark ‘under’, ‘above’ or ‘behind’ the seashells to find the hiding shark’s friend. This is harder as compared to ‘match’ or other bricks because first they have to listen to the word, second they have to understand the meaning of word and third they have to respond with action corresponding to the instructions. Sufficient exposure and experience have to have happened in the story to make this action possible.

By connecting the selected bubbles of activities for the interactive storybook, designers can visualize the length of the storyline and decide whether sufficient or too many activities are embedded. The diagram below is an example of an ideal line for a story. The line is showing the scaffold of activities within the final version of the interactive storybook designed for HAC and their parents. The length of the line and its appropriateness is a pattern observed from the process of iteration. The result from the child is generally better when there is sufficient

time in the exposure and experience ring before moving into the exposure ring. However, there should not be too many repetitions to bore the children. Extra time in any ring and insufficient challenges with the interactions may not be the best strategy.

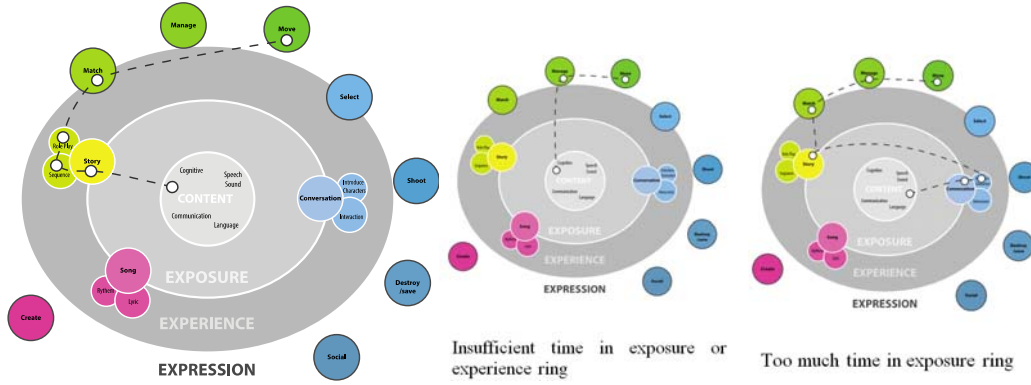


Figure 3. Connecting dots in an ideal scenario followed by two other non-ideal examples

4. Discussion

The use of this framework to design a interactive storybook helped designers to incorporate the learning scaffold and interactive media features in an informed approach and aid the HAC in their language development. Looking from two different angles, parents' reactions towards the interactive storybook within the first session of interaction and the children's learning outcome over a week of interaction, there are significant improvement from them. The full version of an interactive storybook was tested with two parents and both of them were able to accompany their children without any assistance from therapist. Comparing this study and previous studies that utilizes cues cards and questions, this framework has shown to be a promising platform to assist parents in shared reading. Parents gave feedbacks such as 'there should be more of these applications' and they even asked for a copy of the application to use at home. Children who are learning with this application show a significantly increased attention. They are interested to find out what would happen when they say something and are encouraged with animation and music. There are a few cases that the HAC requested to read the story again because they were so entertained by it.

Evaluation being one of the limitations for this framework is hard to administer and the result of the testing is hard to quantify. Unlike guidelines, it is hard for designers who are using this framework to check what is missing or what needs to be add-on. We could try to use the definition of 'better' from user's perspective to decide if the storybook is better or not. Being an assisting platform for parents to conduct shared reading, we can see how much assistance is required by parents to successfully guide children in reading. These could be very subjective, but therapists could help by coming up with a set of cues or examples that could help parents in their interaction. The list could then be used as the assessing criteria.

Another way to assess the effectiveness of the story is through the amount of words learnt and the time taken to learn it as compared to conventional learning methods. It is important to note that the experience/emotional components and parents' perspectives are missing from this type of assessment. Additional assessment should be included to ensure the interactive storybook is all rounded in its approach. In our study, we manage to convince a

parent to use our interactive storybook over a period of time. The three year old preschool HAC was able to say a few words in his first attempt to read the word. Quoting from the therapist, the outcome is good because most of words in the storybook are beyond his Peabody Picture Vocabulary Test (PPVT) age level[3]. PPVT is the standard test used by the clinic to assess the language of the child. After a week practicing with his mother, he was able to use the word ‘behind’ accurately in one of the games embedded within the story. It was indeed a very encouraging moment to witness his progress.

5. Conclusions

During the process of creating these interactive storybooks and condensing the insights for this framework, we understand that more work needs to be done. The framework is not perfect. Although it encompasses most of elements required for a successful integration, there are areas where other like-minded designers can further improve these interactions for this group of children who could listen and talk like other hearing children. The disadvantage in hearing should not be a hindrance in their language acquisition process and being an able-bodied contributing adult. Hence, we hope this framework would inspire more work and be a starting point for discussions in this development of design.

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