Thesis: Tangible Sentence Train

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Abstract

How can tangible technology aid children in learning and what are the implications?

My research paper discusses the explorative design process of creating a tangible sentence construction train and the implications of tangible computing in the classroom. For inspiration I looked into learning style methods and tangible computing projects for children. I aimed to follow the methods of Participatory Design and Cooperative Inquiry as part of my design process, but found reasons to explore different methods.

My final prototype uses a train to provide digital support and encourage an effective way to support task interest, information retention, and sentence structure, as well as facilitate creativity and team problem solving skills for children of different learning styles and skill strengths. By allowing children to construct their own sentences with responsive train cars, I found that children were able to discuss class material and ideas in a fun way, as well as find explorative ways to bend rules and engage in play.
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**Concept description**

Included are two scenarios of a tangible sentence train that children could encounter and experience in a classroom environment; the first one would be if the train was used as a sentence constructor and the second one could be used to recall sequences of information.

*Sentence train – “It’s all going according to plan.”*

Yesterday, the teacher read a story about the Coast Salish aboriginal people of Canada. Today, there is a question on the board relating to topics that were discussed yesterday. Each group of students must complete an answer before the end of the day. Tony, Anna and Cindy are the first group to participate during free period. They leave their desks, walk up to the train station and start to pull out some train cars. They discuss which type of words they should use and they try to remember as much information as they can from the story. After much back and forth, they start to form an answer to the question on the board. Once they have agreed on the sentence, they excitedly drive the wooden to the train station, and receive a green light for each of their words that have been chosen correctly. After each correct word is accounted for, their sentence is read aloud. One student writes down the sentence as their team’s final answer. The children congratulate each other and let the next team know that they can begin.

*Event Train – “Third time’s a charm.”*

The children are required to make a sequence of events covering today’s content. They have sentences that are scrambled and they must order in the correct sequence of events. Eventually, the children agree on the order of the tasks. They drive it to the train station and they receive a green light every time their next sentence is found to be in the right place. They receive two green lights and then one red light. “Ohhh nooo,” the children exclaim. They then reverse the train, to try out a new combination for the third sentence, while discussing this out loud.
After readjusting and running the train through again, they find that they have five green lights, and the red light has turned off. Suddenly a celebratory song is played from the train station! The children cheer and know that they have completed the task successfully.

*General Explanation*

To explain how the tangible sentence train works, I have described two scenarios of how the artefact could be used in the classroom. To review, the children would be given a certain topic or question and asked to create an answer, or recall information. They would use train pieces with words on them to create sentences and could be specific about which type of words need to be used, which can be colour coded (to identify parts of speech or comparable ideas). After a group is finished one story or sentence, they would be able to test their answers. They will load the train with the words and drive it to the station to make sure the sentence makes sense. At that point, the children are rewarded; green lights are lit up for each correct word and their sentence is read aloud at the train station.
Lamberty (2004) has a hypothesis that:

‘A dynamic, constructionist environment used over time that allows exploration of curricular content in an artistic, expressive way, coupled with reflective activity that highlights connections between the expressive and content domains will promote:

1) Sustained engagement with the content area,
2) Choosing to engage with the expressive medium, and
3) Substantial learning in the content area.’

I did not have the same hypothesis as Lamberty, as I did not know what to expect starting the project. However my intentions were indeed similar: To engage children with a tangible artefact that could teach or review relevant educational content.

My research goal was to use a strong design process to conceptualize and prototype a tangible learning toy to assist with language skills for nine and ten year olds who require writing assistance. I’ve looked into many tangible toys and games, tested out different types of hands-on activities, looked for ways to keep energetic children more engaged in material, and tried to find learning tasks that would be transferable to an interactive project.
1. Introduction - Problem Domain

There are two sections of which I would like to briefly identify as the current problem domains. Each supplies a different set of problems and limitations; education and learning and also the field of tangible computing for children.

1.1 Education Concerns

‘Mastery orientation’ as defined by Antle (2006) is that ‘children need the opportunity to actively participate in learning experiences and to develop a sense of competency.’

In the class setting, children are generally taught basic social skills, how to handle authority, structure and also learning strategies on how to understand information and build cognitive skills. However, not all children learn in the same way, and the current education system generally supports children who are able to learn these skills conventionally, while others can be left to struggle to learn basic educational concepts.

Different types of learners respond to different stimuli, and some are better attuned to learn by using their hands, or moving their bodies. Tactual learners ‘cannot begin to associate word formations and meanings without involving a sense of ‘touch’ (Dunn 1978) and kinaesthetic learners ‘need to have real-life experiences in order to learn to recognize words and their meanings.’ I found these two learning styles particularly interesting, and have tried to include some aspect of multi-sensorial activities into my project that children from different learning types can learn from and add to.
My interest was also to work with students with additional educational needs who require personal assistance, but who do not have diagnosed disabilities. A ‘diverse learner’ describes a student or child that can possess a single or number of qualities that can requires sensitivity, possible assistance or a new way of digesting educational content. There can be existing barriers for these students such as those learning English as a second language, students with a shorter attention span, and can also include students with learning disabilities. (New Visions in Action 2004)

1.2 Tangible Computing for Children

A number of digital projects have explained advances ranging greatly from digital software based to embedded technology, including technical devices for children’s’ learning experience, but not many have specific relevance to the educational environment. ‘If a system offers the information and tools you need to perform a task, then it is a useful and relevant system.’ (Löwgren and Stolterman 2004)

Marshall (2007) criticized tangible computing for not having more ‘evidence on the benefits of tangible computing’, more focus on ‘learning activities’ and something more ‘concrete’ and relevant tools to develop specific learning outcomes.

There have been a few design approaches to aid people with disabilities, (O’Connor 2006) and amnesia (Wu 2004), but the projects themselves stayed fairly close to memory systems using PDAs. Many projects have placed their energy on learning process and collecting ideas for designers, but don’t necessarily address an existing problem or suggest a permanent intervention. Most themes of the projects have been more on the explorative side and less relevant to skills and materials that students must learn in school.


1.3 The synthesis between education and tangible computing

I considered that perhaps the literacy skills and confidence of weaker students could be strengthened with the use of feedback, reward systems and an immersive focus, giving more opportunities to help diverse learners succeed such as in Papert and Cavallo’s (2004) Lego Mindstorm projects. Löwgren (2006) uses ‘immersiveness’ as a use quality to describe a valuable interactive tool, and I think particularly useful of a tangible one. We can look at immersiveness as also having ‘focus on an activity and a deep feeling of absorption’ while also being enjoyable by being able to make a mundane task to ‘be made fun through design.’ (Blythe 2004)
2. Research Topics/Inspiration

There have been two main areas of research that have been used as inspiration throughout the design process. The first was research into the theoretical and empirical studies: including literature on learning styles, Montessori teaching. The second focus was on practical studies and papers regarding tangible technology for children and game-like possibilities from recent conferences such as IDC (Interaction Design and Children) and TEI (Tangible, Embedded and Embodied Interaction).

2.1 Using Kinaesthetic and tactual learners to inspire design

Dunn and Dunn (1978) describe that kinaesthetic and tactual learners need a different learning focus than how the average student is expected to learn in a classroom. I looked into learning style teaching methods that are catered towards different types of sensory input to aid the comprehension and development for different types of learners. The multi-sensorial method of teaching is to integrate visual, auditory, tactual/kinaesthetic mixed activities that children are able to learn and explore to develop the best route for them to learn.

Montessori methods consist of ‘a sequence of activities and materials designed to enable the child to teach himself,’ which they do with a ‘built in ‘control of error’ which provides the learner with information as to the accuracy of his response and enables him to correct himself.’ (Orem 1978.) To help make ‘control of error’ in a visual connection, the words can be organized by nouns, verbs, and adjectives. Colours and symbols can be used for repetition and recognition of parts of a sentence. I have visited Swedish and Canadian Montessori preschools and found their methods and tools were the same. ‘Children, have certain tendencies toward movement, order, and exploration of the environment. They have a need to classify and clarify through their sense the random impressions they receive from their environment.’ (Orem 1978) When children are taught to read letters they start to trace the letters in sand and grainy surfaces to learn ‘tactile discrimination.’
Alborzi (2000) describes that the ‘physical environment’ (used for teaching) can offer children:

‘(1) A truly active multi-sensory learning experience;
(2) a social opportunity for learning among many co-located children;
(3) an intrinsically motivating experience (otherwise known as fun).’

The inspirations that I took from multi-sensorial activities were: from the ‘use of self-correcting equipment for introduction and learning of various concepts,’ as suggested by Daniel Brynolf (February 15, 2009) a hands-on approach to learning with the assistance of skill specific toys, creative activities in the classroom that will interest different types of learners, provide clear structure, but also creativity and some element of play. Also the need for use of memory taught with repetition, progression and the need for internal reflection helps to strengthen senses for students that may benefit from it, including students with focus, motor weaknesses.

2.2 Related Works: Tangible Computing for Children

A number of the research papers led me to evaluate the usefulness of child centred designs in tangible computing with some of the following benefits: supporting trial-and-error learning, allowing participation of multiple users, and being able to ‘feel and own the environment and will be actively engaged and not lose their interest easily.’ (Xu 2005) and use ‘situated learning and manipulation of objects as support techniques to understand the context and physicality of the content’ (Marshall 2007).
2.2.1 Why Tangible Technology?

If tangible technologies are built properly, they can benefit children in a multitude of ways; letting students act intuitively and concentrate more on the tasks at hand than the tools, (ready to hand rather than present to hand (Dourish 2001)) supporting trial-and-error learning, facilitating participation of multiple users, giving children the chance to ‘feel and own the environment and will be actively engaged and not lose their interest easily’ (Xu 2005) and allowing designers to measure or use ‘situated learning and manipulation of objects as support techniques to understand the context and physicality of the content’, as well as ‘gaze/gesture monitoring during interaction.’ (Marshall 2007)

‘We are moving toward a philosophy of design that acknowledges both the place of computers in the world and the importance of the body and physical environment with and around the interface itself.’ (Bolter and Gromala 2003)

Tangible Technology allows us to ‘interact directly without graphical interface.’(Dourish 2001) Dourish spoke of a few terms that help define some meaning when looking at tangible possibilities that seem to adequately describe any hands on artefacts or material. ‘Embodiment’ enables us to ‘posses and act through physical manifestation’, as well as being able to interact with our world ‘making it meaningful creating manipulating, sharing of meaning through engaged interaction with artefacts.’ It makes use of ‘emotional memory’ and ‘enforces a positive experience to team work (cheering and accomplishing a shared goal)’ (Willis 2009) It also offers us the advantage of using that which is familiar to us ‘real objects, situated perspective, relationship special action, settings, configurability of space’, ‘relationship of body to task and physical constraints.’ (Dourish 2001) Children have a general sense of what a train is, what it does and how it connects. An additional property is for new formations of use, and organization to take form. The users are ‘more in control of how activity is managed’ [and the] ‘community of practice determines shared systems of meanings and values, acceptable to community over time.’
2.2.2 Review of Educational and Tangible Projects

The following section will review and compare tangible projects for children to inspire my objectives. Initially, I looked into existing projects that interested me that included using embedded tools for exploration purposes such as the Tangible Camera (LaBrune 2005), Tangiflags (Tangible Flags for locating and pinpoint locations (Chipman 2006)) and Hybrid Toys (Mediamatic 2008) for musical exploration and promoting movement and collaboration. However as I expanded my search into educational toys, I found some very rich and intellectually stimulating projects that make sense of a context, encourage children to story-tell, offer free play with strict content that provides intuitive interfaces such as Block Jam (Newton-Dunn 2003) and Flow Blocks. (Zuckerman 2006) Other types of games and puzzles offered assistance with a digital aid or prompt which was also helpful in tracing the steps and progress of the students while solving a geometric puzzle such as TICLE (Scarlatos 2002). It also helped the designers to keep track of the children’s interaction and time allocation, results (speed of completion) and increased difficulty with the system.

Situated learning environments like Smart Us Playgrounds (2008) and Hazards Room (Fails 2005) provide a fun, real world context for an educational theme, and almost have the same offering as going on a field trip. Each object or obstacle in the setting links has meaning, is touchable or interactive in some way. This can bring somewhat abstract ideas and 2D images into a realistic or tactile context, while allocating tasks, physical games and goals for the children. I have some interest in knowledgeable artefacts, which refers to physical objects that have information stored inside them. When these artefacts are linked or shared, a limited amount of interactive feedback is provided, such as lights, sound or digital information. Music Pets (Tomitsch 2006) encourages younger children to encourage creativity, build communication skills and explore colours and sound. The most interesting outcome for the Music Pets was the secret audio communication form that the children had figured out how to develop.
Block Jam (Zuckerman 2005) composes music with different configurations of interactive blocks and programmable series of clicks. The Flow blocks were the result of a research study by a Montessori inspired project that aimed to build ‘generic structures’ that had a level of abstraction as to be interpreted in different ways by the children, as well as offer ‘multi-sensory representations’ and encourage discussion and create analogies. They began their study with the demonstration of flowing of water and counting cookies, and went on to build blocks that could represent the same themes. The magnetic blocks can link together, provide power, change the instructions of the path (speed up), and probes which can count and provide probability statistics. Their purpose was ‘not to encourage any specific, real-world visual forms, only to increase the chance that children will create analogies to the abstract processes, rather than the physical form.’ (Zuckerman 2006) What I appreciated most about this project was that the children could see if their construction was right, because a light would run through their block formation while children were building.

TICLE (Tangible Interfaces in Collaborative Learning Environments) is a software system that helps children to solve math-related problems using a Tangram (geometry shaped puzzle). (Scarlatos 2002) A group of children is given a set of physical puzzle pieces and a specific goal configuration and the system is a tool that monitors their progress. TICLE hints if it detects that the group is stuck if there is a lack of movement or progress. The groups with the aid of the TICLE system proved to have a better chance of being able to solve problems and kept students more focused with ‘more time discussing approaches to the problem.’ (Scarlatos 2002) This project offers extra assistance to children who were more likely to give up early because the question was too difficult and improved the rate of success as hints along the way keep the groups motivated. Encouragement such as this was great to have for students working on a difficult problem for children. The project demonstrated a proper ‘structure of the learning environment, nature of feedback and level of challenge’ which are ‘key factors which promote or inhibit ‘the development of a mastery approach to learning.’ (Antle 2006)
The Hazard Room (Fails 2005) and Smart Us playgrounds (2008) have brought questions and concepts into physical spaces with obstacles and artefacts that actually involve a lot of physical energy to run around and interact with the projects. The Hazard Room teaches children the dangers of environmental health hazards while comparing virtual and physical environments about how to handle each hazardous situation. In the physical game, as a group identifies hazard props, wanders around the environment and places the items in the safety box and receive verbal feedback if their choices were correct. In the virtual setting, the rules are shown in animations. SmartUs uses technology and games in a playground environment to teach a variety of learning objectives and incorporates exercise. The games are set up using a computer station that controls the game with visual and audio feedback, posts and a grid to set up the space.

A more recent project at MIT has designed ‘Siftables’ (Merrill 2008), digital learning blocks that have mini computers with several examples of impressive learning software embedded in a sleek exterior able to: create music, mix paint colours, do simple math equations and create narrative stories with video animation. Some aspects of the interaction qualities can be inspiring and transferable as we think about the shape that a learning technology can take and ways that we can teach different lessons.

2.2.3 How tangible design offers educational benefits

To develop an activity that tackles written and spoken correlation of different learning styles, we’d have to have a physical artefact that children can; touch, move and manipulate physically, see symbolically and textually, hear and talk about. In addition to these needs, the device would primarily have to be interesting for the children and worthwhile for them to engage in and keep their attention.

A benefit of ‘interactive computer-based learning environments’ is that ‘the student can manipulate and influence the processes in progress.'
The expectation is that activities of this kind will provide instant feedback and, hence, make learning less abstract.’ (Ivarsson 2003) If the children are able to piece a concept together (such as the concept of language and sentence creation), they would be more likely to make sense of the information own their own terms and receive a new chance to remember a lesson. With children being able to take charge of their own learning within a team environment, there could be increased development in ‘accountability, responsibility, and power, management of challenge.’ (Löwgren and Stolterman 2004)

Using a specific group of children with a collection of strengths and weaknesses helped conceptualize what a regular student (as well as a diverse learner) would be able to gain. As a group, the diversity of students involved can allow students of all skill levels to contribute to problem solving, whether it be: by brainstorming and discussion, arranging and putting the pieces together, moving the train, testing and retesting theories, or writing down the sentence in the end. On March 10, 2009, Åsa Harvard described by email that this method of checking as an ‘editing phase’ changed into ‘proofing phase’ as the sentence is loaded on train. The children would also be able to take some direction from the spelling of topic words, as they are reading, saying and using a context for the words in a sentence, before they begin to write. This form of sentence construction would allow students to build confidence, be more willing to try new combinations and ideas with relatively minimal emotional distress, as they are facing a personal/ team challenge and not aiming to win the favour of a teacher. (Dina Willis April 19 2009)

The developers of Tangiflag said ‘the physical act’ (of placing a flag) ‘provides a strong mental connection because the child is situated to compare the artifact with the real world environment that it represents.’ (Chipman 2004) I am not sure if that is the case with abstract representations every tangible project, but I was willing to explore sentence construction with physical manipulation.
3. The Overall Design Process

In this section of the paper my design process will give a short background on my main design partners, and then will review methods that I intended to use and methods that I actually used.

Child involvement on projects can generally range from simple inspiration using methods such as: Persona creation (Alborzi 2000 and Antle 2006), Technological Probes (Chipman 2006) drawings and journals (Wu 2004), to giving the children material to work with (Alborzi 2000) collaborate and discuss projects with designers (Tomitsch 2006), using them as brief user testers (Ryokai 2004) or extensive testers. (Scarlatos 2002) It does seem clear that there is increasing support from schools for design research occurring in classes and there is a dedicated attempt to use the full participation of children as designer partners.

3.1 Background

I was extremely fortunate to have Dina Willis’ support in all activities, as well being able to borrow some of her students. There were seven students aged nine and ten who attend her Learning Support classes who were part of the complete process, from interviews to user testing in the eight or so times that I visited the school. In the Surrey school district, it is necessary to get full permission from the district, school, principal, teacher and parents to be able to conduct a research activity in a school. In the appendix in the back are the necessary documentation and permission forms.

3.2 Design Intentions

Originally, I was hoping to carry out a very thorough, by-the-book design process and documentation of my every thought and children’s every move. The methods that I intended to use, I may have used for inspiration, or altered as I needed them, or did not end up using at all because it seemed unnecessary in the context. Due to time constraints, unforeseen events, and the natural flow of activities this process seemed to veer in and out of Cooperative Inquiry and merged with
game interventions (or more Action Research). This however did not negatively affect the project or the outcome as it is realistic to expect that circumstances and plans change. The research methods I did use are part of ethnography via group interviews, Cultural Probes, game creation/Cooperative Inquiry, prototype development and the user testing.

3.2.1 The intended step-by-step design process

The following was my initial process that I intended to follow, I will comment below what worked and what did not work.

1. Carry out a number of ethnographical studies and observations to determine context and possible areas to work in.
2. Provide Cultural Probes to find out more information of how the children work and think, and what they like to do.
3. Get children to give ideas for learning toys with use of participatory design and low-fidelity prototyping.
4. Develop some hands on activities that have the use qualities of different directions the project could take and test them.
5. Develop two low fidelity prototypes: Test in two different groups, talk about what they like, don’t like and the challenges of doing it this way.
6. Build one or two higher-fidelity prototypes; and work with children/instructors to develop the content.
7. See if the use of Personas or Walk through user testing will be helpful.
8. Study varying degrees of collaborative involvement, how much is group based, what skills they need to have in a group, what can be learned individually and what can be taught and learned and how that can change between students (and what openings tactile/digital technology might have to take).

3.2.2 Outcomes of my Intentions

For my ethnography studies, I went to the first session with the intention of just being a fly on the wall. Immediately the children wanted to know who I was, what I was doing and how I was involving them in my project. Within ten minutes they were giving me a list of ideas. When I attempted Cultural Probes, I found that I may have planned too much and did not have an idea of how long each activity would take. Each session was 40-45 minutes and it took two sessions to
carry out a number of activities, some of which I could not accomplish. My unsuccessful probes were getting all of the children to draw the time on an analog clock and recall what they were doing at that time, and trying to get the children to bring two pictures from home of things that are important. I was aiming to start a story or game with these things, and I had to reschedule when I was coming in, an assembly interrupted the activity and decided that three days of Cultural Probes was too much.

After getting to know these children, I revised my thoughts about the need for Cooperative Inquiry. The children already gave me a large list of ideas on the first day and I felt that asking them to make paper versions or sketches would produce similar ideas, so I moved on. The hands on activities that I actually developed were somewhere meshed between Cultural Probes and intervening game exploration activities. I also did not get the chance to study too deeply into team development or how they would carry this out in a regular classroom.

I also had the intention of asking the children to use Clöe (character developed from a game exploration activity) as a persona and ask how she would go about the activity, as well as what her thoughts, and suggestions might be. This proved to be a difficult concept for nine year olds to think about deeply and only provided reasonable yes or no answers to questions. Instead I had the children describe in their own words the activities that they carried out, which was quite interesting. I tried to get them doing a live ‘walk through’ but it became difficult to keep half of the group engaged in something else, keep the other students away from the train and for the student to think and speak about what he was doing. This perhaps should be carried out while another teacher is supervising the rest of the class, and taking the child to a separate room.

Each of these obstacles were not really a hindrance to the project, but directed the way that the research should pursue. The following section will explore my actual methods and outcomes of my process.
3.3 Actual Design Process

My actual design process covers Ethnography, Cultural Probes, Game Exploration/Intervention, Prototyping and User Testing. I observed classes, interviewed students and teachers about the needs and weaknesses of their students. I also asked for opinions on toy ideas with the students, as well as tried to get an idea of what they did during their free time and what they thought about school. I became increasingly interested in working with students who are often overlooked in the education system to build an explorative but structured system using embedded tools. I wasn’t able to extract any solid ideas from my brief ethnographic studies, but was able to determine some boundaries in which to stay within.

3.3.1 The Process Overview

The list of research and development steps that I took is included below. More detailed descriptions will be given in the following section.

1) Carried out ethnographical studies to determine context and possible areas to work in.

2) Provided Cultural Probes to find out more information of how the children work and think, and what they like to do.

3) Brainstormed and developed some hands on activities that have the use qualities of different directions the project could take and test them on the children.

4) Developed a low fidelity prototype to test in the core group, talked about what they liked, didn’t like and their visions of what it could be useful for or how it could be improved.

5) Built two versions of higher-fidelity prototypes; (one with just lights, a second one with lights, sound and playback) worked with a teacher to develop the content.
4. An In-Depth Look at the Design Process

Before I began brainstorming and considering ideas for what might be useful as a tangible learning toy, I spent some time doing field studies with classes; observing and interviewing educators, caregivers and students to get a deeper look at what some specific needs of the students (and educators) are and how educators would generally approach them.

4.1 Ethnography:

To learn about the class environment I sat in on a few sessions and classes from the two schools; the main group was from Hyland Elementary and my secondary group was Anne Alexis’ class from Mary Jane Shannon Elementary. I was mostly getting a feel for the classroom environment, watching students work in teams, hearing what they were learning about and what the regular instructional time looked like. The regular classrooms have roughly 25 students, but the individual session that Dina Willis leads is about seven students who require extra assistance (45 minutes outside of regular class, four days a week) to complete lessons and class work. I spent seven sessions with them, and one additional day that I used for preliminary interviews. I observed and interviewed Ann’s class and some of her students for two hours on different days as well as spent an hour interviewing her.

4.1.1 Educator Interviews:

To have some basis as to what some of the concerns and recognized issues that educators have about how students learn, I spoke formally with a principal, two elementary teachers and two Montessori preschool instructors.

When I spoke with Joanne Berka, principal of Hyland Elementary, I asked her about the largest problems for children today for the age
A group of eight to ten year olds. She mentioned comprehension, organization of ideas, not being able to write more advanced than a speaking tone and putting mental and vocal ideas together (particularly on paper).

Dina Willis commented that her perceived issues for the specific group of children that she works with are: Pinpointing details, being able to keep their attention and focus, team development and crowd control (distraction, noise, and attention). She works with a number of children in different classes that receive either isolated blocks of time with her, or she comes into classes and provides extra assistance. Guha (2008) mentioned that ‘many designers have included children with special needs in the process of designing technology for children with special needs.’ However my aims were to support a group of learners that needed a different method of learning. In their regular support class, they cover the same material at a slower pace and are given more attention. Students are able to progress and leave the learning support class if they are able to catch up to the regular class pace without assistance.

Ann Alexis, from Mary Jane Shannon Elementary, thought her biggest issues with her class were: that the students don’t read instructions, (which cause a lot of repeating instructions because of misconceptions) and issues with editing (including spelling, punctuation, capitalization and clarity). She finds the best way to address that is through using buddy editors and independent editing. Ann also mentioned that the hardest skills to teach were: Writing and reading, details, proper one sentence answers and paragraph structure. She gave me an example where she used group learning successfully. The students completed a body systems project on posters in groups, and had to present in teams. Members of the team took on roles like dietician, physical trainer etc. and had to report speaking from that role. The reading groups are organized according to skill level and the students had to identify main ideas and topics to report on them. When asked how students learn best, Ann reported that the students need a balance of cooperative and independent work, and personal evaluation.

The summarized version of the information that I received from three public school educators basically came down to the fact that children at
the age of nine and ten struggle to write. Organization of words, sentences, ideas and details are difficult for children to be able to voice on paper as well as being able to keep children on topic and comprehension.

4.1.2 Montessori preschool teacher interviews

In Surrey I interviewed two Montessori preschool instructors and asked if they could speak generally about Montessori teachings to find out if I could match up some of their hands on activities with a tangible device for learning. I was given a tour, shown some of their activities which were all individually based tasks. For the most part, children manage of their own time after they are taught one on one learning how to use an activity. They learn about practical life skills, organization, and learn about subjects such as math and reading by using and handling ‘real’ objects. Their methods were very intriguing to me, and I could see the relevance between the many hands on activities these children had, and qualities of having tangible or embedded tools.

What are the main aims or methods at Montessori?

- “concrete to the abstract”
- using letters and objects to spell the object, to “manipulate physical objects”
- “being “self paced”
- “advancement” – once the child masters one activity, hints are taken away, minimizing the control of error.
- “multi-sensorial” activities
- use of “physical discrimination”
- There is a ‘control of error’, such as if words are matched incorrectly, there will be a piece missing, a secondary piece that is incorrect or there will be some other indicator that a previous choice was incorrect. With questions, there are matching pieces with the exact number, if something is out of order they will understand that they have a problem and ‘something is wrong’ when they see another piece that doesn’t match.
<table>
<thead>
<tr>
<th>Example of lessons</th>
<th>Writing Method example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Introduce a physical quantity (ten beads) and a symbol (‘10’).</td>
<td>1) Control of error (colour coding introduced, matches symbols)</td>
</tr>
<tr>
<td>2. Master (noun and given symbol (triangle) to identify those words.</td>
<td>2) Advancement (symbols of: noun, adjective, verbs choices)</td>
</tr>
<tr>
<td>3. Written language shown with rhyme/vowels, sight words, physical objects they can see and touch.</td>
<td>3) Identifying symbol with a physical object/word (circle, triangle, circle for ‘Chicks lay eggs.’)</td>
</tr>
</tbody>
</table>

The Montessori instructors were able to give some ideas of useful hands-on learning activities and perspectives that helped to clarify later decisions in my project.

4.1.3 Child interviews

I thought this would be an important part to the research, for children to identify where their problems are and what they struggled with. When it came time to interviewing, I realised that this was probably too much information to reveal to stranger, and not something that you would want to reveal in front of another student. I tried to keep to more generalized questions and find out what interested them as well.

4.1.3.1 Mary Jane Shannon Students

I shadowed Ann’s classroom a few times and interviewed about ten of her students. I had hoped to test some of my higher fidelity prototypes on some of her students, but unfortunately the timing did not work out as well as clarification about which students to speak with and getting permission from parents. Currently she has eight out of twenty five students who require special assistance with the English language, with learning skills or that receive other types of special assistance.

I asked a number of questions to students in groups of two about favourite school activities, most hated subjects, what TV shows and games they like and whether or not they get help from their families
with homework. The some of the general favourite subjects were: French, Art and Social Studies, and the most hated were Math and also Social Studies. The only interesting information I found out is that most that receive help with homework get it from their brothers and sisters and not from their parents. Getting generalized information was interesting, but it was also very time consuming and not really useful to my idea generation.

4.1.3.2 Student interviews at Hyland Elementary

This group turned out to be the perfect group to work with my project. They were very energetic, able to test for use and ‘misuse’ without being advised and were very creative and vocal about their advice and criticism. They asked their teacher why I was there and I explained my research. They proceeded to give me as many ideas as they could about what would be a good idea for a learning toy. Some were some very abstract ideas, but I liked the creativity and tangibility of the form that some of the ideas could take.

- car with a math questions. Its movement depends on correct answers.
- math helicopter-hologram that moves up and down (for positive and negative answers).
- cat robot that can help with spelling.
- clock that tells time and asks math questions.
- helping hand (this was not elaborated on)
- writing pen (this was not elaborated on)
- science robot that walks and asks questions.
- a book for visually impaired students
- Gameboy that helps with reading
- Spinning globe with no names or labels and requires guessing and hints to label it.
- Number chart, that helps with counting
- Futuristic glasses- for research
- Stepping lights- providing questions to step on
- Teddy bear-Mimzy (a movie) toy that says things

When I brainstormed with the children about the types of learning toys they could think of, they spontaneously thought of many creative ideas.
There were many detailed and practical uses for a math toy, but were somewhat vague about how a reading/writing toy could actually assist. Their ideas about toys having movement capabilities were interesting and I continued to consider that quality.

Figure 15. Example of Children’s responses from activities 5 and 4 respectively.

4.2 Cultural Probes

Cultural Probes were more useful for me as tools to get to know the children’s personalities and strengths as learners and also what was interesting and amusing for them instead of using individual interviews. I worked with the students to do two days of hands on activities about various topics such as learning, school, entertainment, games, and media. I was aiming to try out different tasks with the themes of writing, touch and teamwork, analytical and visual work (drawing) and also testing out the ideas of space and task locations. The children really enjoyed these activities, which were somewhat unorganized, so it was difficult to keep them on task. I did however learn a lot what kinds of activities would not work.
Activities:

1) Pick an available toy, and write some words about it on stickers and stick them to the object.
2) Using multiplication flashcards, work in teams to review (guess) the answers, and note improvements after running through the questions twice.
3) Using four words (that were supplied), make a sentence (by adding words).
4) Draw your classroom and where you sit.
5) With a blank clock, make up a time and write it on. Switch your clocks with a partner and record what you were doing last night at that time. (Only three girls worked fast enough on previous activities to get this far, and they basically had to be walked through: What time should I put? How do I make the time? I don’t remember what I was doing).

Figures 16-19. Examples from the children’s commentary of the toys

<table>
<thead>
<tr>
<th>Spiderman</th>
<th>Guy Smiley</th>
<th>Cheetah</th>
<th>Puzzle Ball</th>
<th>Angel Bear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eyes, red, blue, mask, man</td>
<td>Smiley, hairy, blue, goofy, interesting</td>
<td>Happy, tiny, black, yellow, funny</td>
<td>Yellow, ball, green, pink, round</td>
<td>Beary, white, fluffy, soft, happy</td>
</tr>
</tbody>
</table>
4.2.1 Conclusions:

Among problems that arise when one tries to over plan an activity and doesn’t consider the small amount of time one has (45 minutes once a week), some of the main important points learned were:

1) The children need simple instructions. Much simpler than how I was giving them.
2) They often need hints and encouragement.
3) Fancy utensils become a distraction. (Example: mechanical pencils with different cartoons caused discrepancy and were being comparing and traded through the first activity.)
4) Unorganized management and team work allows for unrelated socializing.
5) There needs to be follow up after an activity so that they understand the purpose.
6) The concept of Flashcards was not fully understood and the rushed time factor didn’t play well at all.
7) There needed to be a lot of repetitive instructions.
8) Only one set of directions at a time, or they were forgotten or completed in the wrong order.
9) The activity has to be interesting, and someone has to be there to organize and command attention.
10) Fairness or perception of fairness is very important to children and lack of fairness will halt the progression of an activity.

Overall I found the use of Cultural Probes was very interesting and useful as an icebreaker for a designer in the classroom. They gave me an idea of what my constraints would be, what their knowledge base was in certain areas, and also about how much time I could expect an activity to take. The most important information that I received from the probes were that instructions must be simple, tasks must be intuitive, tools have to be easy to use and team work must be structured.
4.3 Encounter with Cooperative Inquiry

Researchers use the term Cooperative Inquiry which ‘enable[s] children and adults to work together to create innovative technology for children’ (Tomitsch 2006) using methods such as Cooperative Design, Participatory Design, and Contextual Inquiry. I tried to use the children as informants, testers and their ideas as inspiration for new ideas, games that involve touch and movement, however I didn’t use them directly as design partners to develop what the sentence train would look like or ask for help building or designing the prototype.

4.3.1 Realisations

I had the intention of following using children as design partners. After reading Guha’s (2004) experience with Cooperative Inquiry with Druin’s team I realised that I did not follow methods of ‘sketching ideas with art supplies such as paper, cardboard, and glue to create low-tech prototypes during the brainstorming process ‘ or ‘capture activity patterns’. The way that the research activities unfolded, it did not make too much sense to follow the pattern of low fidelity sketching and prototyping. I believe that this particular group could come up with strong brainstorming ideas in low-fidelity, but would also require more time, direction and it would have to be brought up at an appropriate time. I wanted to move onto Cultural Probes to learn about more specific skills that they had. I felt that asking the children to make the learning toys in a low fidelity way would be losing some time and produce some of the same results as our first interview session. I did ask the children to comment on their team’s use with the low fidelity and higher fidelity train activities, but did not ask for their observations on other teams testing out the activity. There were times that there was one team testing and another one waiting to test, and they would often have a hard time focusing on what they should be doing, and would either want to watch and touch the train, or to start doing a completely different activity such as drawing on the whiteboard.

My research methods were more similar to Paperts and Cavallo’s (2004) Lego Mindstorm study with adjacent youths and action research. In the Mindstorm project for youths who’s academic skills were below those of the average student, the main goals were to: ‘develop the habits, attitudes and sense of self needed to be a ‘disciplined and successful
learner,’ in a practical way that requires ‘independence and discipline’ for the ‘design and construction of personally meaningful projects’. (Cavallo 2004) They were able to interject artefacts and use ‘hands-on creation of concrete artefacts’ to allow for ‘multiple learning styles’ so that students can take pride in their achievements. Their methods seemed closer to that of Action Research where the ‘researcher conducts the research activities while participating in the intervention and simultaneously evaluating the results.’ (Jensen 2005)

4.3.2 Cooperative Inquiry Dialogue

Alborzi (2000) describes that having children as design partners has six assumptions, some of which I was unable to use or address. In this section I will be engaging in a commentary on each of the assumptions and how it did or did not apply to my research.

(1) ‘Each team member has experiences and skills that are unique and important, no matter what the age or discipline.’

I agreed with this, a number of the students I worked with had stronger writing skills, art skills, verbal skills, creative ideas etc. and they all contributed in a useful way. I usually left it up to them to use the skills or participate in the way that they felt comfortable or to offer to take a role that they feel comfortable with.

(2) ‘A new power-structure between children and adults must be found. All team members must see themselves as partners, working toward a shared goal. Therefore, design methods must be found that enable all team members to contribute.’

This did not happen for me. In the Canadian classrooms, children are to address adults usually by formal last name. I was immediately introduced as Miss Hall, and basically not instructed otherwise to use my first name. Also this was an energetic and vocal group, and normally would require crowd control and organization of letting people speak or instructing them to follow directions which definitely did not put me on the same power level as the children.

(3) ‘Idea elaboration’ is the ultimate goal of the design process. All team members should build upon ideas from both children and adults’.

This was definitely true.
‘A casual work environment and clothing can support the free-flow of ideas. This includes sitting on the floor, wearing jeans and sneakers.’

We did have a free flow of ideas and I tried to take every verbal idea into account. We were working in their regular support room and had them working in different areas and teams each day. Some days we were standing, sitting or writing on the floor or sitting at the tables. I didn’t have any restrictions or ideas about the clothing but we were working in a time constraint each time.

‘All design team members should be rewarded.’

I had a minimal student budget and gave out stickers and pencils for their help and giving out candy or sweets has been prohibited recently in Surrey schools to children. Although I believe that being able to do creative tasks with me (instead of reading), was already an anticipated activity.

‘It takes time and patience to build an effective intergenerational design team. We have found that 6 months is needed before a team of children and adults can become truly effective’.

I saw the group over a period of six months and by the end I think they were quite comfortable with me and our group conversations were calmer and able to go deeper, while listening and building on each other’s comments.

My conclusions about Participatory Design and Action Research left me swimming somewhere in between. In my case I found it useful to take input, ideas and analysis from interactions as the inspiration for my project. I found the method of intervening with tangible constructive activities to be effective and relevant for me and I will explain in more detail its successes in the Low Fidelity Game Exploration section.
4.4 Low Fidelity Game Exploration

This section describes my modification of Cooperative Inquiry and Game Interventions/Exploration and what I could draw out as inspiration. Originally, I thought that Participatory Design would be a large part of my research. However some of the activities that I was organizing with the children were too open-ended and vague. This ended up causing confusion and not helpful to direct the students to draw or create in the direction that I was aiming. I felt that the low fidelity activities and games that I tried out on the children, gave me much more useful information. I tried to get the children to take activities home for the Cultural probe portion and was told by teachers that it would be unrealistic to expect the students at their age to complete and bring back the activity when I needed it, so I did not try to make another take home activity for them.

I decided that I would offer the children different ways to be creative within a stricter context and see what traits and opportunities could be interesting and continued. I would get some advice and thoughts about the type of project that should be created and let them be involved in the rules, objectives and change some of the activities according to their questions and feedback.

The three main game interventions were:

<table>
<thead>
<tr>
<th>The Story-mapping of Clöe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synonyms/Antonyms matching game</td>
</tr>
<tr>
<td>World Direction Game</td>
</tr>
</tbody>
</table>

4.4.1 Story-mapping

This activity was about creating stories collaboratively with the flexibility of post-it notes and organizing details on a visual surface. This was my first full length activity. At this point, the children were a little easier to keep on task and I started to learn responses how to keep them productive. I had a volunteer body and a volunteer artist who would trace out the body of our ‘main’ character. As a group I had the children nominate and vote on the name, and city that our character had/was from. Then, I had each child answer some questions about the main character, which I might later refer to as our persona (Clöe from Las Vegas.) Then I had the categories: Title, Introduction, Main points, and Conclusion labelled on the body of our drawn figure in: Head, shoulders, body, and feet to go with the visual of the formation of a story. I had the children also categorize the paragraphs into:

1) Things you would notice upon first meeting her
2) Things her friends would know
3) Things her family would know
4) Things only she would know (trying to go deeper and deeper into her character).

They seemed to enjoy this activity and being able to reorganize and place them as they wished. I gave them a lot of creative freedom with this task, and it was up to them to come up with ideas and organize them as a group. The down side was that they were easily distracted when it wasn’t their turn.
4.4.2 Synonyms/Antonyms Game

This activity looked at the organizational skills and pattern recognition of the children. I made three different lists of words: a primary word, a synonym to go with the primary word column and an antonym column. I had the children in three groups, one to choose how the first column should look, group 2 matched their words with the words that group 1 displayed and group 3 had the task of matching their words with the previous two columns. The words were also grouped by colour. (All of column one was one colour, column two was a colour similar to column one, and column three was a completely different colour.) They seemed to enjoy this activity, although there was some discrepancy over who was allowed to ‘do it’ when, and by the end the whole group was trying to finish the lists. It was also understood that like colours went together, and could not be mixed within the columns. I saw some valuable pieces of this game as the physical rearranging of words in a team allowed for everyone to take some part.
4.4.3 World Direction Game

A third activity that I tried with the group was one that was mostly based on physical movement and direction. I had eight pieces of paper on the floor for two teams and each team received letters which corresponded with North, South, East and West. I had one child score keeping with the answer key for questions, and the team mates took three questions each by stepping on the corresponding letter as an answer. They all seemed to enjoy this game, and we tried out receiving help from the team (which they liked more) and individual answers. They liked the challenge of the questions but also liked stepping on even a paper surface. The children would often ask to change the rules to see how much they could get away with, which I found interesting. The boys in the group tended to be more competitive and being more concerned with fairness, while the girls looked to teammates for help and suggestions. An interesting thought was that I started out with one set of rules, and the children would constantly ask about ways to change or bend them, such as: ‘Can we help our teammates with the answer?’, ‘Can we point to where they are on the map to help them’?, ‘If we step on two answers, can we count both of them?

The children seemed to enjoy this activity the best, and I felt the instructions were easier to follow and for the children to understand. Unfortunately, this activity caused children to yell and stomp, so perhaps this type of activity would be better suited to outdoors.
4.4.4 Design openings

The book, ‘Funology’ gave me a very strong breakdown of what the cycle of creative imagination possesses and what I was looking for in my artefact: ‘Exploration’ related to experience and senses, in which reflection can initiate ‘inspiration’ in the forms of writing and group discussion, ‘production’ deals with ‘organization of narrative content’ and ‘standard rules of story construction’ and ‘sharing’ involves the children being able to show off results and ‘verify production of others.’ (Blythe 2004)

Some of the transferable qualities and tasks from each activity had some potential to be useable again in a different game context. In general the children enjoy story-telling, talking and being creative. For them, the focus on content has to be secondary, and there has to be a fun or crazy objective. To develop structure (sentences or story), there has to be a fun way for sentence development to make sense and still focus on the content. There also has to be some reward that offers opportunities for the team and individuals to feel a sense of accomplishment and show off or demonstrate something at the end. I would consistently ask the children what they enjoyed, didn’t enjoy about the activities and how they could be improved. They are a very well spoken and honest group and would always give me some valuable ideas for the next round.

In Story-mapping, I was dealing with a story construct, watching their writing and organization skills as they were developing a girl persona and organizing the story on a drawn person’s body to visualize how an introduction, main points, smaller details and the conclusion of a story could be mapped out on the head, body, extremities and rear end/or feet. Story Mapping provided a strong problem solving activity for children to be creative and ‘edit’ portions of the stories collaboratively with the quick movement and rearrangement of post-it notes. It allowed children to express their ideas by written means and verbally, and guess, or reason what their ideas mean, or if there were spelling mistakes. It became clear that there needed to be some motivation for the children to keep active as a team, or to accomplish a clear goal so that one or two students do not complete the task without the assistance of bored classmates.
The Synonym/Antonym activity had some interesting aspects because it provided children with a problem solving activity and required them to rearrange words with little negative consequence. It also helped establish a way to organize teams into having tasks without being competitive. Teams had to make unanimous decisions to whether or not their choices made sense and we were able to read through the final answers and decide as a group if something sounded like it needed to be changed. I thought that the collaborative decision making and also rearranging would be useful characteristics to have for a learning toy.

The results of a map directional game advised me to stay clear of obviously competitive activities and watch how after a period of time, children would change the rules to suit their own means. The geography game proved to be more competitive and fun, but besides the movement factor, the game felt finished. After these trials and some time to contemplate, I was able to think of useful concept.
5. The Concept: The Tangible Sentence Train

‘Metaphors, however, have a larger purpose, precisely because the computer is now understood as a medium. A digital metaphor should explain the meaning and significance of the digital experience by referring to the user to an earlier media form.’ (Bolter and Gromala 2003)

To explain the relevance of a tangible sentence train, we can examine some of its parts and functions. There is an engine, several cars and a caboose that connect together, as well as usually flashing lights and sounds surrounding them. They follow a track that leads them where it needs to go, and there is a beginning and end destination.

My goal was to make a tool for children to develop sentences using train cars with words to reaffirm information that has recently been taught to them. There would have to be in a particular order of words in a sentence and children can use trial and error and articulation to make their decisions. Due to the toy-like and practical nature of the activity, it would make sense that every piece and connection has to be relevant and easily manipulated, (changeable, and not simply for aesthetic purposes). The use of LEDs or movement feedback can help to reinforce as to whether their sentence would be considered acceptable (right or wrong.) With the use of some simple technology, I was able to show their different levels of progress and let the students know how many of their choices were correct. Their errors needed to be made obvious; there needed to be encouragement for the children to try out different choices to make it right (to make the green light go on.) Also utilizing the support of peer groups will also add useful information to my study,
and hopefully bring to light examples to make the children feel more comfortable about risk taking and build confidence as their familiarity with the structure and understanding with the tangible material grows.

The metaphor of a train started to appeal to me as I began to think about the confusion and structure of actually making sentences and stories. The students that I’ve worked with can each write a sentence to get their thoughts across, but stringing a number of sentences together can be quite difficult for them. In my Synonym/Antonym activity, the initial word and a synonym were similar colours and an antonym in an opposite colour. We could construct sentences using blocks with words on them to create sentences in a particular order that children could attempt with deliberate exploration or trial and error articulation, and receive digital feedback as to whether their sentence is considered acceptable (right or wrong.) What this type of activity would provide is: A collaborative activity that would facilitate team discussion and decision making and the ability to self-correct. One of the most frequently asked questions to teachers is: ‘Is this right so far?’ A progress confirmation would help children feel more confident in their work, such as the students working with Mindstorms, ‘more daring and more expert in their work in a self-reinforcing virtuous circle.’ (Cavallo 2004)
6. Prototyping and User Testing

My aim for prototyping was to create a physical manifestation of my idea in low and high fidelity prototypes. I was able to explain my idea of the sentence train with my supervising professor, Åsa Harvard and worked on fleshing out some ideas of what it could look like. I tried out the activity for its interaction qualities in two sections: physicality of a train and rearranging cut up sentences on pieces of paper, all of which must be completed in teams. User testing was carried out with the introduction of new functions in the prototypes. In this section I will explain the activities, content, reaction and interviews carried out with each trial run.

6.1 Low fidelity prototype

To have an understanding of what qualities were important and to find out at all if the train could be used for a rearrangement activity at all, I tested out a simple idea with a wooden train and some main components without the use of technology.
6.1.1 Activity 1: Problem solving and Low-fidelity feedback

For the first low fidelity prototype, I asked Dina to provide me with four sentences that had been recently covered in class to be the answers for a rearranging activity. Two examples of these sentences are:

‘In the summer, the Copper Inuit collected different kinds of berries and birds’ eggs to eat.‘

‘The main sources of food for the Copper Inuit were seals and caribou.’

The first action was to split boys and girls (mostly so that they wouldn’t protest or argue) and get them working on a sentence to rearrange. One student was the ‘train station director’ also known as the child with all the answers. It was his job to assist and check the answers of the two teams. We tried different ways of giving hints such as:

1) Telling them which were wrong,
2) Switching the wrong words’ places, 
3) Pointing to the words, and
4) Saying, for example; that two words were backwards)

Once their sentence was complete, they taped or rewrote it on a cue card and attached it a wooden toy train and dragged to the ‘station.’ Their reward was to ‘play’ with the train, station and some characters such as Spiderman, as they were able to pick him up as a passenger.

Unintentionally, I gave the boy’s team (which was one person short) a much harder sentence and although it took them longer, they were able to keep on task and enjoy the activity, especially when they were able to complete it.
6.1.2 Activity 2: Levels

The second activity was broken into three parts. I tried out the idea of breaking longer sentences into separate tasks (testing to see if it was easier for them to complete the sentence in less pieces, but more ‘stations’ (e.g., re-arrange the five words for the first part of the sentence, and then go to a second clue and rearrange the other five words of the sentence). This activity took some time to explain. Some of the children got confused and tried to mix words from different parts of the sentences. After successful completion, they again put their sentences in the trains and dragged them to the station where our ‘station conductor’ approved their sentences, or sent them back to be edited.

6.1.3 Activity 3: Creating own sentences

In the third activity the children were given a choice of topics such as: Food, clothing, shelter and transportation, and basically asked them to recall every piece of information on a chosen topic that they could think of that they either remember from class, or the previous activities. Each team had a scribe and they each had at least five or six sentences. Both teams used the information that they had covered in the first two activities, but were also able to write successfully about three or four sentences related to the topic. After teach team finished, they proudly read their paragraphs out to each other.

6.1.4 Conclusions:

I quickly realised that if I didn’t keep the instructions simple, that there would soon be a number of questions and a lot of confusion. After that, I tried to give instructions in about three general commands and make sure that it made sense. When I was able to describe: How to rearrange the sentences so they make sense, attach them on the train cars and run it past the train station, I was happy to find that the children understood the task and we able to complete it with little encouragement or hesitation. The three activities were carried out within a 45 minute period, and worked out really well for the students and the teacher. Dina was impressed that the children stayed focused.
without frustration or giving up on the activity. I also got some good feedback from the children about how the train could give different types of feedback while they’re working through the activity. Testing out how to give hints proved to be useful. After limiting the train station’s leader’s ability to correct the students, he tried out different things like saying ‘there are four words in the wrong place’, or pointing to certain words without being specific. This inspired me to think about how children could easily have their errors identified and find ways to hint how to correct them.

Figures 26 - 27. Children testing out the RFID tags, running the train past the station with the RFID reader.

6.2 Higher Fidelity Prototype

When I had confirmation that the low fidelity activity was successful, I started to work on a higher fidelity prototype. I wanted to replace the ‘train station director’ with (hinting) technical feedback. After wiring and coding the Arduino board with RFID reader to read RFID tags and send some light output we were able to start testing with feedback and LEDs to assist with writing, sentence construction and editing. The children are asked to rearrange words into a sentence into a correct order and the words are read by the RFID reader. Green lights are lit for every correct corresponding answer given, a red LED is lit if incorrect.
Figure 28. Diagram of working prototype.

**Configuration**

Each RFID tag is attached to a word, and each tag is given a number in the order of one to seven. The train cars must be dragged near/over the RFID reader. I used variations of destinations for children to take the train; a make-shift cardboard bridge, a wooden Brio bridge and also just had a ‘station’ set up with blocks and images on paper. Seven green LED’s and one red LED are attached to the side of the bridge that give feedback as to the correct progression of the sentence. The first tag must be correct to get the first green light, then second, third and so on. If the first answer is incorrect, the children must take the train pieces back and try to the correct first word, (regardless of the order of the remaining tags.) Once the children have received seven green lights, a play back sound is given off by a Piezo speaker and a pre-recorded answer is read-aloud by the computer. Currently the RFID and Arduino board are plugged into a computer as a power source; however it would not be too difficult to use a nine volt battery as a power source and to find parts to play back sound without a computer.

This is a very simple set up used for testing, but allows for easy testing of two cases; one correct answer and allowing children to create their own sentences. (I read the children’s sentences and manually placed the RFID reader in the order that they arranged it so that they received positive feedback for their work.) The Appendix holds more information about the Technology, as well as video material of use on the DVD.
6.2.1 Day 1: Does the technical system work?

When I brought in a high(er)-fidelity prototype to the same group of children, my goal was to have a few levels of progressing content and user test with the children. The ideas I tested out were word association games (creating colour trains), creating longer sentences, and creating stories (paragraph trains). I wanted to see if the progression seems to make more sense for the students. Each team’s answers were audio recorded, but there wasn’t time to play it back for them in the activity. However, as children completed and checked their sentences, they also looked forward to recording them.

6.2.2 Day 2: Feedback from User Testing

The user testing involved the students trying out the prototypes and giving their opinions in semi-structured interviews. This helped me to pinpoint small modifications that need to be adjusted and ask for the children’s and teacher’s opinions and observe how they interact with the project. I primarily used video to document the test sessions, and also had group interviews based on the daily process.

At the beginning of the session, I asked the children a number of questions regarding the previous day’s activities. I asked if they could explain what we did yesterday, how the train worked, what they liked about it, what its uses could be and transcribed the following responses:

Q1. What did you like about the train?
- “It was exciting.”
- “It was fun and cool and exciting and awesome.”

Q2. What did you think of the lights? (as feedback)
- “That was awesome” (unanimously- well one started and the rest chimed in.)

Q3. What would you think about adding sound?
- “Would be more awesome.”
- “Possibly.”
- “Fun fun fun!”

Q4. I asked about what they thought about the idea of projection on the wall and received some blank stares and some confusion about what I
meant. One of the other children tried to explain what a projection was and the other children looked disinterested.

**Day 2: Visible issues in the Activity**

After the interview, I offered the train activity again with some adjustments. One of the children missed the previous testing session and I asked a teammate to help that student become familiar with the activity. In the previous test session, we found that sometimes the words would end up upside down, or on the wrong side of the train which would make it difficult for the RFID reader to detect. The first few times the children ran them through they were actually reading the sentence in nonsensical order. (The train was reading from right to left). It also meant that the children wouldn’t actually be able to read each word of the connecting train in the right order, (so it would appear as: “houses. in live People”). I put out the train pieces next to the tags in the order they should be placed, so that the children could actually read the sentence as they were testing it.

The children enjoyed the rearranging of words (sentences of seven words), attaching them to the train and dragging the train through the station. Something I noticed is that the children are also tempted to take the words physically apart to be able to scan them.

**Post Activity interview:**

At the end of the second day of the high fidelity prototype testing, I also asked a few questions of the group to get a summary of their experience and what they noticed about it.

**Q1: Did you notice the colours in the words?**
“Some were verbs and some were nouns.”
“Yeah... What?” (Child who thought she was listening and then was surprised by the answer.)

**Q2: Did anything funny happen?**
“When everyone was saying: ‘we win we win, we lose, we lose.’”
Summary:

This activity proved to be a lot of fun for them and I felt I was on the right track. With the second activity, the children were able to make their own sentences with some of the example words. I noticed that the ‘child in charge’ gave instructions verbally and caused some spelling mistakes that could be later corrected by other teammates. The group would have to agree that a constructed sentence made sense to the team. It was also interesting that the children believed that they were in a competition against each other.

I put the tags in order so that they would achieve all green lights, (I was testing the idea of having loose sentence creation). The students would consider it ‘winning’ when they were able to complete the sentence and somehow decided that it was a competition between groups to finish first. It was fascinating that one group developed an articulate decision and tested their sentence from the first car to the last car, and the other group were taking the pieces one at a time using trial and error to get immediate feedback.

As I had spent a lot of time working on content for the children, my next concerns was to integrate some more digital aspects to use as a reward system, (and make them more excited about completing a task).

6.2.3 Day 3: Feedback, Symbols and Sound

I knew that this would be my last test session and my main objectives were to: Implement sound play back, replace symbols with the previous coloured words, to find out what they remember from the sessions and to find some new children to test run the activity. At the beginning of the session, I asked the children to recap what we had covered in the last day, (partially for me, but also for a student who was missing the previous day.) Collectively, they summarized the topics, and one girl came up with some new information based on something she was able to remember that was talked about.

Preliminary Group Questions

I wanted to go into more detail about what the children understood, how they would explain to other students or people what the activity
was about, how to use it and what its purposes might be for. Collectively they were able to recall all the sentences that they had gone over. Some of their language was tacit, and was explained using body language (pointing, physically showing how the pieces sit and move to other students.) The learners were very good at being able to identify its use and potential. In one case, a student tried his best to explain the technical part of the system.

Q1. Can you explain what you did?

“Yesterday, we came in and started making sentences with these things and then there’s two groups and it was basically like a competition. And then we have to go like: faster, we have to make sentences before the other team. And the other team did too and they won so we were losers.” (Group laughter)

“You get this little tag it checks your answers. If it’s wrong it becomes red, if it’s right it becomes green.”

“We won when they got the answers right.”

Q2. Why might the train be useful at school?

“If there’s no LST (Learning Support teachers) coming, it can check your answers.”

“When you get stuck on something, and there’s no teachers to help you, it’s like a test and you don’t know the sentence, you try to make your own sentence but you’re not quite sure so you put it inside the train station and the train station is basically like your teacher who’s going to help you make your sentences/mistakes and something like that “(and sticks around?)

“It can help you. Because say if you were learning about it, it could help you in class or school. And then when you’re older it can help you ‘cause you could also make sentences.”

“If you’re little and you don’t know how to make sentences, you can try it on the train so it'll be fun for little children and then you can just put it through the station.

“If you want to help a little one learn, to make it fun for them but you want them to learn the words and learn how to do it, so you put it on
the train and if it lights up when they say the word correct. They get to choose it, they get to put it on and u get to put the train through and see if they made it correct.

“Because instead of someone saying it, it takes a long time for them to say it, but this thing glows and it tells you if it’s dark right, light is wrong.”

Q3. Are there any suggestions about how it looks?

“Make a box that doesn’t break and a train tracks and tunnel with lights.”

**Impromptu test lesson**

Due to some critique that I received from a fellow classmate, I wanted to explore ‘graphic textures, sense of touch, shapes, characteristic materials, symbols or perhaps even different behaviours could be alternatives.’ (Brynolf 2009)

Previously, some of the children mentioned commented that they learned about nouns and verbs. However Dina had to run a short lesson in five minutes to teach the main concepts, which corresponded with Brynolf’s (2009) question: ‘How do we convey in which kind of grouping the words have been grouped to a child who does not understand the underlying concept?’ So this became a testing of his question. I had also planned to give a pre and post activity oral test, “Do you know what a noun, verb, adjective are?” and ask them to give examples from the activity. After the brief lesson, I supplied these sentences: (which were provided and recorded by two groups came up with in the last session.)

“Coast Salish people use cedar because it doesn’t rot.”
“Coast Salish need cedar to build boats.”

I asked the children to match the symbol (circle, triangle, square) to words (noun, adjective, and verb) in the sentence and to place it with the RFID tag and word onto the train. In two teams they were able to rearrange the sentences quickly, (with a few more nouns then they needed) but a happy tune and their sentence would play back. I then had them leave their sentences near the station and had the opposite team try their sentence (to simulate if it was a regular classroom and had the ability to pick up someone else’s sentence and test it. After reading particular sentences, I supplied RFID tags to be placed correctly in their particular order of the sentences and loaded on the train. Then,
the children received positive feedback (e.g: happy song played on the piezo speaker and a playback of the voices that we had recorded prior).

Additional questions:

Q1. What did you think of the happy music at the end?
   “That was cool.” “It was like a happy ‘yay’!” “Like we won the lottery.”

Q2. What did you think of being able to read and test other people’s sentences?

Q3. Did you like the happy song or the sentence better?
   Three preferred the ‘Happy song.’ Two preferred the read aloud sentence. One liked a song, then the voice to be played. One wanted someone to say good job! And then play a song. One gave an idea of having a sad song if they got it wrong. While another commented then people will ‘Try to get it wrong.’ I found this to be insightful speculation for a nine year old to be aware of how the artefact could be ‘misused’.

Results:

Every time the children tested their sentences, everyone would get excited and want to be involved with touching and leading the train. Even when I supplied difficult sentences to rearrange, the children would not give up on their tasks. They anticipated success each time they found themselves closer to the final answer. Seven out of ten times, the groups would already have the right answer before they tested it. Each time there would be some form of celebration as they received positive feedback and I found that an auditory congratulatory message seemed to intensify their reward experience.

The children seemed indifferent when asked about the preference between symbols and colours, but symbols were also fairly unfamiliar tools to them. They admitted to symbols being more confusing than colours, but it served for a preliminary round for these purposes. Six out of seven preferred colours, but they all didn’t mind using symbols. They really enjoyed the sound playback, and were pretty excited to recognize the voices. When I had them switch trains and test them out, they seemed to enjoy that and hear the end result (the playback) of the other team’s sentences. Many of them were able to remember the two sentences that were arranged and I was able to get examples from the students about what nouns and adjectives were, and what examples
were. There were also some interesting social dynamics of students delegating tasks and some conflict with fairness.

6.3 User Testing on Non Design Partners

I was aware that children who were part of the design process would have different input and learning outcomes to those who have not. I did not have much time, but I was interested in testing out the train on children who did not help develop the concept. Originally, there was an intention to try out my low fidelity and higher fidelity prototypes on Mary J. Shannon elementary students, unfortunately due to the lack of time and classroom coordination it was not possible to work with Ann’s students past the ethnographic stage.

I was able to run one short session with two volunteer children from the same class as my core group, (although they are not part of the special session). Due to a time crunch, I was not able to get written permission from their parents to videotape the session, but thought their reactions were useful nonetheless. They were able to rearrange the sentence, load it on the train, and confirm their answer. I explained the concept to them, and one of them took ownership of the sentence while they tried moving the train together. They had the sentence right on the first try, “Sound is caused by vibration.” I also gave them symbols for nouns and verbs which they were able to identify with some instruction.

They ran the train past the RFID reader played both the happy song and read the sentence aloud. I also had them try out an ‘incorrect’ answer to see what happened. They both were excited about the fact that they were two of nine students who had tried out this activity before and that most of their other classmates had not. I asked for students in the same class because I knew that they had had former lessons about sound, and I also learned that they didn’t know much about parts of speech. I simplified for this activity by making nouns and verbs different colours and getting them to match symbols to ‘like’ colours. One of the differences I noticed about the new testers was that it took a little more time for them to get to ‘play’ with the train. The previous students would quickly revert to this being a game or free play when they got the chance to touch the train, while the new testers seemed to wait for encouragement from me to ‘play.’ However they did start to play with the train as a toy near the end, by making ‘choo-choo’ noises. The two
students enjoyed the activity; one commented that ‘This is fun’, while the other student agreed.

6.4 Conclusions from User Testing

Although I know that the children enjoyed the activity and collectively they were able to recount sentences and topics from the day before and the week before. I agree with Ivarsson (2003) and his comment that ‘The rich environment provides a number of cues that assist the students in handling the task, but there is no indication that the relevant conceptual distinctions are mastered in the manner intended.’ I have not tested each child individually to recall how much of the material they remembered from the activity or if they have learned any new information. Given time and people restraints, I feel I may have missed useful information; however a group with designers, interviewers and evaluators with longer than 45 minutes per week would have definitely been in a better position to carry out individual pre-tests and post-activity tests. I am confident that the activity would result in positive results if testing was pursued, as the supervising teacher noted that students being ‘engaged’ with the material is one of the largest obstacles to overcome and we had accomplished that.
7. Design Decisions

Design can be seen as a deliberate process; we are ‘applying concepts, strategies and interpretations of what is seen and formulate a plan.’ (Löwgren and Stolterman 2004) This section covers my design research and process and the number of conscious decisions that I have had to make. First I have done so by organizing my thoughts and decisions with a supportive basis that I felt could help justify my end position in two charts that cover the details of some of the directions that I have taken, both from the education standpoint and from the technological side.

7.1 The Educational/Task oriented Decision Table

This table brings out some decisions that I have made about the use of the tangible sentence train, involved activities and its purposes.

<table>
<thead>
<tr>
<th>Decisions</th>
<th>Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primarily group based as opposed to individually based activities</td>
<td>Teamwork and vocal discussion gave the students different ways share, express and do the work, and possibly make content easier to remember. Each team had to agree on the sentence to progress to the ‘checking’ train station.</td>
</tr>
<tr>
<td>Deciding to nix timing and competition based activities</td>
<td>Competition proved to be more fun for some children, but also more stressful for others. Having a time limit made children more conscientious of their answers, and also produced more tension on the children to ‘perform’ correctly.</td>
</tr>
<tr>
<td>Using train station as a proof reading tool and not as an initial construction tool</td>
<td>Some children become reliant on trial and error checking capability of the train and forgot the purpose of testing the sentence. In one case, the team was separating train cars and testing them individually to receive positive feedback. They managed to disorder their sentence by the end and forget their original and end answers.</td>
</tr>
<tr>
<td>The train metaphor versus blocks, individual tagged words or cars</td>
<td>I decided on the idea of a train because its cars can have a strong representation of order and connection between words of a sentence. It also allows for a lot of flexibility as to moving parts around and still demonstrating an importance and a role that the train has, of being able to move strictly to accomplish a task (such as moving from point A to point B, delivering, picking up passengers etc). A toy also gives children a tool that is intended for them and allows them to mix ‘play’ and task time.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>The purpose of coloured words versus non-coloured words</td>
<td>The distinguishing of words with colours will make it more visually recognizable for the children to understand that patterns of words are different. The implied values of colour may also work as well (similar shades are similar words etc.)</td>
</tr>
<tr>
<td>Strict and Open-ended sentences Opening the possibility that there is more than one possible phrasing or sentence.</td>
<td>When children learn a game, they need to first be exposed to the strict rules so that they can follow a guideline and make clear determinations as to what decisions are right and wrong. Once the guidelines have been established, flexibility can come in and creativity can flourish while the game players can try to bend and stretch the boundaries that have been set.</td>
</tr>
<tr>
<td>Content To be reflective of what the children are learning in class</td>
<td>I was looking for the children to be able to recall information (from class) to form the answers in their own words. It is my intention to use the train as a tool to support recently familiar words and information.</td>
</tr>
</tbody>
</table>
**7.2 The Interaction/Technology Table**

The purpose of this table is to explore some of the many technical arguments and reasoning for what has or has not been implemented.

<table>
<thead>
<tr>
<th>Technical Decisions</th>
<th>Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why go interactive at all?</td>
<td>The most valuable parts about having some level of tangible interactivity in this project are that it offers more complex feedback and rewards for the children. The technology actually keeps the group immersed in the activity and focused on the task with very little to learn about the tool.</td>
</tr>
</tbody>
</table>
| Immediate feedback versus Delayed Feedback | Receiving immediate feedback such as green and red lights for a partial answer could assist children to realise efficiencies of particular combinations and choices. However providing immediate feedback may take away from the anticipation, thought process and enjoyment of the children being able to do the 'final check.' It also seemed to take the focus of the content away and create reliance or a 'cheat' method of solving the question.  
   
   The testing of receiving delayed feedback allowed children to be able to keep immersed in the question and gave them a strong anticipation for being able to check their work and receive positive feedback. The team creative thinking process was able to work for longer if the children aimed to complete a right answer on the first try.                                                                                                                                                                                                                                                   |
| Not to play aloud every single word before the sentence is completed. | The children I was working with could read single words. A main issue for their age group proved to be connecting thoughts and ideas together. One teacher mentioned that the train: “Is not a reading tool...” and such a device would be more age appropriate for children beginning to read, of which many educational toys exist.                                                                                                                                                                                                                                                                                                                                 |
| Not to include more digital technology (changing screens or displays, or being) | I found that with any new technology introduced, the children were fascinated and temporarily distracted. With minimal lights and sounds, I was able to quickly explain its purpose and how to use                                                                                                                                                                                                                                                                                                                                                   |
| reactive to other blocks) | it and the group found to be satisfied enough to start the activity with too much confusion.  
I thought that the children might lose the tactile and pliable qualities of directly manipulating sentences if it deals with parts that they cannot touch or control. |
|---|---|
| **Rewards** | The main reward intended for the children to be that the children receive confirmation and confidence in their answers as they receive progressive green lights and finally a congratulatory tune and a playback of their complete sentence.  
Loading and placing the train pieces together and being able to drag them over the bridge (on top of the RFID reader) seemed enjoyable.  
A non intentional reward presented itself as the children were able to have ‘free play’ momentarily with the train after their sentence construction.  
In one exercise, three students took turns guiding the train, making sure it didn’t fall off of the edge, making train noises and discussing what would happen if they were to crash. The short discussion on the consequences of drunk driving also seemed to come up. |
| **Not providing projections on the wall of answers for display purposes.** | When I questioned the children about the idea, they were not that interested in its possibilities and were much more interested in sounds, songs, noises and hearing their own voices.  
Although with their negative feedback on this idea, I dropped the idea and continued with sound feedback, which was positive and enjoyed by the children. |
8. Reflections and Questions

This section will discuss the reflections and feedback given to me by Dina Willis, as well as a longer section about my reflections throughout the process and use of the Tangible Sentence Train. My reflections then started to branch into a number of questions specific to the practicalities, concerns and implications.

8.1 An Educator’s Reflections

Dina was very accommodating and also did a lot of footwork on my project being able to be developed and tested in her school. She also assisted five out of seven of my sessions and was always encouraging with feedback. In terms of what a teacher’s answer key or interface might look like, she mentioned that simpler was better and she would rather type in a phrase onto the computer rather than manually presetting the train and locating each of the words. I also asked for her opinions on what she observed from the children, and what benefits and potentials the train might have.

Her comments on April 19, 2009:

1) The students were engaged the entire time; we didn’t have to tell them to keep on task.


3) Hearing language is one thing, but having to sort out language to make sense would also attach more ownership/meaning to the learning.

4) Lights: Add novelty and a game aspect. They want to get the green light (took away from negative emotion, making it easier to try again and created personal challenge versus pleasing a teacher.

5) Working as a team, cooperative learning can accommodate all the levels of learning/abilities. It allows children to use their strengths; for example: children could use oral language to participate with their team if child can’t read or write as well, some students could be the scribe to write down the answers, and some children could physically put the pieces together (if nothing else) to feel each has contributed something.
8.2 A Designer’s Reflections

The aims of this section are to reflect on my own process and the outcomes that I can apply to future work. An important result of project was that the tangible sentence train’s purpose became a digital device to be used as a secondary support tool for children to discuss their reasoning and test out their thoughts and not a replacement for a teacher giving an introductory lesson for the children. It could also provide an interesting outlet for designers to explore the emotional memories of children and how that can affect learning. The sections covered are process, prototyping and use, requirements, benefits and how this exact project could be improved if repeated or continued.

8.2.1 In the Learning Environment

I found that time could be vastly underestimated when it came to developing lessons, running activities and crowd control of two groups. This probably impacted the time I was able to spend getting empirical evidence. I also found recording video without assistants can be extremely challenging. For example, it was difficult to catch and observe all of the interesting material on video, while giving directions to a team.

Each time I visited the group, the material that the children would be studying would change. This made preparation a little more tedious, and may have cost me some time I could have spent working on prototyping. Usually four days to a week before I was ready to run the activity, I would have to get in touch with an educator to confirm class time availability. Two to three days prior to the activity, we would have to communicate again to talk about the sentence content. Although I had a rough syllabus of prospective learning objectives from the beginning of the year, it was difficult to guess when certain topics would be covered; in the end it is up to the discretion of the main instructor.

8.2.2 Process

My design process through to prototype development has been amazingly informative and a large growing experience for me and I still feel there are many areas that could have been improved or additional aspects would have helped strengthen my research. I learned many
things about the research environment, working with external constraints, tangible computing and what learning toys would need. The particular characteristics that I found that exist in my project, I believe coincided with some strengths of other tangible research that I admired, such as the research inspired Montessori Flow Blocks and the helpful TICLE.

Near the beginning of my practical research, there was always the concern of how much I was to involve children in the design process in the making of a tangible learning toy and how it would affect the outcome of the project. I found that Cooperative Inquiry was good inspiration to keep my project focused on the needs and entertainment of the children, but I ended up combining this method of Participatory Design with game interventions for guidance, which I believe was successful.

8.2.3 Prototype and Use

I had the personal interest in learning to construct something tangible with Arduino, and still offer a rewarding experience using sensors, lights, sound, tags or touchable components to communicate or assist with writing, spelling or reading. The prototype that I ended with was sufficient to test the interaction purposes of my tangible sentence train idea.

The children intuitively understand how to use a toy train. They are able to engage directly with it, move the pieces together and apart, and physically drive (or drag) it to the end location; signifying the completion their mission. Children were able to test their thoughts and answers on their own, (without the assistance from an adult), used reasoning and trial and error methods to pinpointing where it is that they need work. As they gained more familiarity and skill strength, they also gained confidence and also tried to explore how to bend the rules.

8.2.4 Requirements

When thinking about the open ended sentence creation, it will be necessary to initially have strict rules about how sentence creation is carried out (including nouns, adjectives, periods etc.) For students to recognize there is only one potential answer per task, a number of
capabilities could be added to provide a more complex teaching and explorative tool. The content can be either new or old, and could be inspired by photos, video or story content. For questions with multiple answers, the capability of the tools would have to be more complex. Having two distinct tasks will provide two different learning objectives that are equally as important. 1) That there are certain rules and times where there can only be one right answer and 2) That there will be times that there can be many right answers and that creativity, group discussion and memory of the discussion and task are what can attribute to the ‘correctness’ of the answers. However the ‘correctness’ of the answer will have to be measured in other ways, such as the choice of using particular words to be the indicators of correct answers.

8.2.5 Benefits

One of the other benefits of tangibility that I didn’t expect is that the users can interpret their own uses, joys and creativity of what to do with the artefact. There are special qualities in a half-finished and transparent prototype that allowed the children to give plenty of free ideas, but to also enjoy its simple construction. The learners are able to build and interpret the content as they wish, as well as use the train as something to aid conceptual ideas, and also feed imaginary and creative play (as sometimes they make up amusing commentary, train noises or verbalize short stories that could happen to the train or its passengers). As a teaching aid, educators wouldn’t need to be constantly questioned to check work or explain if the children are on the right track. They could potentially spend more time teaching and have just a bit more interest from a few more members of the class. Willis (2009) noted that the activity gives children more ‘empowerment and ownership over their learning.

8.2.6 Conclusions

As a designer working in the public school system for the first time, I found the logistics to be somewhat slow, but necessary. Once I was able to get started on research and get a design process started, I was surprised to find individual pieces of feedback from different times coming together to guide the direction of my process. I was also delighted to find that the game interventions that I tried out were able to lead me to a useful idea, based on the interactions that I noticed.
My original research question was ‘How can tangible technology aid children in learning and what are the implications?’

To speak about some of the support that the Tangible Sentence Train can give, children are able to benefit in a number of ways. The needs of children who learn by kinaesthetic and tactual learning styles are attempted to be met, children can be immersed in an interesting activity while still learning the class content and manage their own learning by physically constructing and vocally discussing their thoughts. Results will probably differ from alternative groups of students, but I believe that using a sentence construction train that can give helpful hints and feedback that will make the social learning experience more entertaining and enjoyable for the students.

8.3 Unveiled Questions

As I was contemplating my reflections and answers, more questions about implications started to surface. My research gave some reinforcement that tangible technology in the child’s learning environment can be very useful and more fun for children, but also opened up questions that can be relevant to designers working to produce practical uses with tangible computing for children. Below are three sections with my concerns regarding implementation, meaning and social environment of the tangible sentence train.

8.3.1 Implementation

I was able to use a ‘toy’ as a tool, but how do we interest more educators in the use of tangible learning toys and demonstrate validation to them? Is this the right approach? Could use qualities of such as playability’s ‘balance of goals, resources and obstacles in the game’ and elegance perform ‘with as simple a construction as possible’ (Löwgren’s 2006) somehow make the artefact more trust worthy to educators?

In my case, my chaotic prototype creation and improvising user testing of the developing artefact in use of the educational environment had elements of playability of which were just beginning to be explored. There was some elegance in the interactions that the children had with the tasks and tools. The time and experiences with the prototype
seemed to be rich and enjoyable. They were intrigued with the shape that the project started to take and also the bits of technology that they were able to understand and manipulate (such as setting lights off, and hitting the reset button). A more aesthetically pleasing shape would be possible such as the Siftables, but how would the completed form shape the interactions?

8.3.2 Meaning/Ownership

How can the metaphor to be taken further? Is it useful to do so? For possible further development, perhaps we could make the train metaphor even stronger by grounding it in Montessori suggestions; like an incorrect sentence is like a train that cannot move or complete its mission of picking up passengers or crossing over bridges because the sentence train isn’t structurally sound. We could also provide flashing lights for errors or a waiting period for other sentence trains being checked, or provide new levels at each station. Would it make a difference?

How do children bend rules? I believe that once children have started to understand the concepts and experience applying the rules of sentence making, then encouraging explorative or nonsense language could be worthwhile. The fun part of creating an exploratory sentence creator will be the ways that children will also ‘misuse’ the project and the task to be able to create dialogue that promotes laughter.

A few times in my paper I mention the benefit of children being able to take ownership over their learning, as brought up by Dina. Constructing answers with a team, seeing the words coming together, rearranging the train pieces and being able to check and recheck answers (without orders from a teacher) can make the children feel excited about doing the activity and without being pressured. In what other ways can children take ownership over their work and track their own success?

8.3.3 Social Environment

The social dynamics of children and ownership are very interesting and can take a toll on the equality of participation within a group. Sometimes this leader was an encouraging one that would give others
the opportunity to ‘play’, and other times they would be possessive and claim a number of pieces and tags for themselves. Another dynamic that might make ownership complicated would be if children would borrow and use pieces from other team’s answers. Would this cause friction within the class? Or would a teacher set up some rules that no one group has ownership or the right to keep their answers in tact without conflict? There could also be the argument that teamwork will not always build confidence in every environment. Strongly opinionated people may put pressure on more passive ones, or claim ownership to the tasks, possibly decreasing the level of confidence in a shyer student. Could this train activity form some method of distraction in the classroom as well as cause unnecessary competition? The teacher’s personality, the classroom environment and how enforcement of rules are carried out would be the deciding factors.

Should there be a memory or count option to remember which team answers to start a point system? This could encourage children to work faster or try to come up with better answers, but this could also be very discouraging for children who are in lower-point groups, as well as shift the focus from the quality of the sentences to quantity of points that could be obtained. Henrik Larsen (March 30, 2009) also suggested to me that ‘Collaborative learning can actually be very demanding if the child has poor self esteem or low social skills.’ There is the possibility that any objectives that warrant unnecessary confrontation or competition may hinder a fun learning experience.

8.3.4 Last question

These questions could contribute to a research area or be a starting point for another designer to explore. My questions about implementation of the artefact, the meaning and ownership and social environment of the children were of personal interest for me, and may be good starting points for a similar project. The open, generalized question is how an artefact can become more sophisticated without losing its valuable interaction characteristics and positive learning experiences?
9. Knowledge Contribution

In terms of what my research can contribute to the Interaction Design community, I feel that I have a number of points that should be considered when approaching children as design partners and also tangible computing for children in a learning context. The three main topics are regarding my stance on children as design partners, designing for misuse, and the benefits the tangible sentence train offered for its testers.

Figure 29. The Roles of Children in the Design of New Technology (Druin, 2002)

9.1 Children as Design Partners

Does using children for active research make them design partners? Using Participatory design can be useful in prototype development or even idea generation. When designing for children, Cooperative Inquiry becomes a more relevant tool because designers will have to face obstacles and manage their design partners in a way that is appropriate and more effective for the audience. However, there are situations that designers will have to use even more speculation and send in interventions to get idea generation started. In my situation, the children needed specific instructions, examples and focused activities, or I would have lost the interest of my assistants. From experience, volunteers will be more eager to participate and follow directions than a random grouping, or children who have not been asked to volunteer. A select group of students chosen from a facilitator might most likely be a mix of student interest. I was also working with a group that attends learning assistance who are brought together from their class that have a variety of needs, interests, personalities, strengths and weaknesses. However I feel that the children that were my core group were in fact valuable, active participants in my design process.
Looking at Druin, Guha and Alborzi’s various work, and my previous dialogue in the Cooperative Inquiry commentary section; Hyland’s children would not be considered as design partners because they did not help me build an actual prototype. Though, as I mentioned previously, my design process lies somewhere between Active Research and Cooperative Inquiry throughout this partnership with a unique group of nine year old informants. The process worked quite well with me tossing in some ill-defined games and ideas and building rules and goals as the children were testing and playing. The children began to ask questions like: ‘Can I do this?’ ‘Can our team help each other?’ and ‘Can I touch this?’ The children started to frame the activities and I was able to judge what elements they enjoyed, how much challenge they needed, how to coordinate them and how much I should even be involved. The methods that I did use were a mix of Cultural Probes, Game Intervention/Game Exploration, Technology Probes and Cooperative Inquiry, which seems to have a spontaneous area worth exploring.

9.2 Between Use and Misuse

If your project reaches all of its aims and expected outcomes have you succeeded? People are always finding ways to challenge the enforced systems: Riding transit without paying, hacking game codes to receive extra points, or snowboarding out of bounds. In most cases, it’s important for the designers or implementers-of-rules to anticipate how rules will be bent or broken and what the responses should be. Sometimes negative reinforcement is given, sometimes rule breaking is supported and sometimes it’s neither supported, nor discouraged. When there is not a penalty for misuse, this provides less motivation to follow rules. Regardless, there is still a need to have a contingency plan to consider what happens once the rules are not followed. When it comes to game design, or a tool for children there will be countless possibilities for what the uses can be or what they do with it.

Creating systems that can be misused can have interesting outcomes, create interesting content and start interesting discussions. What if the classroom provided an environment for children to explore, providing more information the more an artefact was played with?
Interpretations of use would an interesting study and could be explored further. Already, the train ‘station’ environment seemed to communicate free play, and the children assumed that it was allowed. On a few occasions I had characters such as plastic animals and Spiderman sitting at the station, and the children were excited to collect passengers, load and balance them on the train once their testing had been complete. I did not say anything to encourage or discourage them, I was interested in ‘what students do when they are working in this environment, what the nature of the communication is and what resources the participants utilise in their interaction.’ (Ivarsson 2003) They would play until the next team needed the train or until I told them to stop. It was fascinating to watch, that even when I did not supply extra toys or blocks, how long they would be immersed in the environment and imagination such as saying: “Oh, a person fell off” (referring to the RFID tag.) The children would still take turns leading the train around the station in circles anticipating LEDs to light up, yelling “We got one!” and when they received a red light; “Wait what happened?” As they worked together and took turns leading the train around, they had conversations about crashes, “You’re gonna get into a car accident”, “Don’t drink and drive”, and made their own sound effects for the train and its characters: “Go go go, buzoooom,” and “Trains go faaaaast.”

They also found ways to negotiate turns and leadership, below is a variety of quotes (also on the title page) from the children that I found amusing:
“IT was my turn!”
“Can I see if it’s right or not?”
“I’ll drive it there!”
“Let’s just do one car at a time”
“They don’t let me drive the train. You guys are mean.”
“Can I do it can I do it?” “Yes”
“Is it my turn?” “Ok I wanna do the last three”

In Day 3 of the high-fidelity activity, I did not regulate what they developed and a few of their answers were funny such as “People eat food made out of salmon,” and they were able to record their answers. On Day 4, one student made the comment that there should be some negative sounding feedback when wrong answers are read; “Dun, dun duuuhn” and another student made the insightful comment, “Then everyone would want to get wrong answers.”
9.3 Educational benefits

On March 10, 2009, Åsa Harvard mentioned one of the educational benefits of the Tangible Sentence train that it has an ability to ‘[free] children from the motoric side of writing), also making the activity of building sentences visible and collaborative.’ The choice of immediate or delayed feedback brings out interesting social possibilities; giving the children time and a task to problem solve, the anticipation and the wait that the children must endure before they realise that they have overcome an obstacle becomes a team building exercise. Depending on the complexity of the assignment, they can suffer, strive, and celebrate together, but the consideration of individual work is possible as well. Every child can contribute something, and I found that even the most timid of the group would feel more confidence as to voice her opinions when the group was stuck and would have increasingly more to say as she was able to participate with the train pieces.

Ivarsson (2003) makes an interesting reference to some of Papert’s (1993) writings, that ‘the constructivist position that states that students themselves will discover the underlying principles built into the technology seems somewhat awkward’ and that ‘such a stance is most problematic,’ however short cuts such as ‘visualisations in this case could offer students access to mathematical worlds far beyond those furnished by normal textbooks’ but require ‘an active and attentive teacher mediating the activity.’

What Ivarsson says in this case is that technology cannot replace instructors to teach complicated processes and concepts, but it can aid students with the guidance of instructors in new ways to help grasp new knowledge. In my case, I have not proven that a teacher can be replaced by technology at all, and that there would still be a strong need for a teacher to set up rules, information and boundaries for the students to participate with this activity effectively. It does not have to be technology’s purpose to replace teachers or teach content, in my case it be used as a support tool to review and play with content. In this activity, most of the thinking and work of the sentence train is completed analog style, before the children touch anything digital. The technology is not the main focus; how the children use it and play with it is. Technology becomes the reward for their problem solving.
10. Future Possibilities

In this section I will cover some ideas and scenarios that could be pursued in multiple directions depending on the interest of the designers. Those working with tangible computing, children, education and Computer Supported Co-operative Work (CSCW) may have the most interest in the design process for the tangible sentence train to develop it further. I provide some thoughts on areas that could be explored such as: Emotions and environment, possibilities for fun interaction, and specific ideas and requirements for public and Montessori classrooms.

10.1 Emotions and Environment

If we were using the train’s function as an explorative tool for designers or ethnographers, we could develop the train to study the child’s experience and how to make it more interesting for them, as well as teach adults more about children. Rule bending, misuse, imagination, ownership, ideals of fairness and team building are all issues that have come up in my research. This can be interesting for the ‘investigation of how people use technologies’ such as ‘talk, bodily conduct, the use of tools, technologies and the like, as ways in and through which participants accomplish actions and activities; actions and activities which rely upon, and embody, social organisation.’ (Heath 2000) Rule bending and misuse could help define how to build tangible learning toys that can avoid certain conflicts or develop the weaknesses, encourage misuse for the sake of play, empathize with other children, or simply let them enjoy being children. My more important questions are: How can children demonstrate that they are competent in a subject area in non written ways? What would we find if we continued to explore emotional memory?

If we had children to talk about how the parts feel, provided think-alouds and researched how positive memories are formed, I think there would be more evidence that negative memories are a deterrent to learning. Although I have not tested this area empirically, I believe that the children’s time with the sentence train has been fun and positive, and they have been able to recall fond memories from their work together on a team. In this way, research could be continued on how to
provide children with positive learning experiences versus experiences that discourage children from risk-taking and verbalizing their ideas.

10.2 Fun Interaction

If we were interested in simply making this project entertaining, there’s an endless sea of fun and interactive functions that could be implemented. Colours or shapes of words can transform depending on the type of word, the sentence can give hints as to what type of word comes next, every word could read aloud and words could be spelled and corrected (morphed) by the train station and adaptable parts of speech could be created (e.g.: ‘Brush’ can be a noun or a verb). The train activity could also have a number of progressing levels; go through a series of stops, connecting more and more train cars, have sentences from other teams build or correct upon each other’s sentences, give points for silly messages that still have the required answers in them, or write secret messages or codes (like in the case of the Music Pets.) (Tomitsch 2006)

10.3 Complexity

The progression of task difficulty is important for strengthening learners. Providing material specific to the tactile world, challenges appropriate for the learning levels, as well as allowing children to be more vocal about their reasoning with other children will all help to develop their skill sets. Increasing ability to reflect on the practice of the children should be encouraged. Schön (1987) says that through this, ‘they can begin to gain control of their developing 'artistry.' As confidence grows, children could be eased off of one hinting tool to add difficulty. Children could be given more assistance pinpointing error (telling where and why that word is wrong, e.g.: ‘you chose the wrong noun’.) Challenge can be added with more car choices, multiple trains and different ‘stations’ that include multiple questions or tasks.

Some possibilities could be to allow for more than one correct answer. Smaller children could create their own words (allowing for more free play) and have them read back. Older children could work on forming
stories including specific parts like concluding sentences and thesis statements, or be given the freedom to create their own questions for other students.

10.4 Classroom Use

Looking at some practical suggestions more specific to the classroom’s needs, this system would need to be implemented with a permanent (off side) work station that students could turn to during designated task time. Use for assignments would require extra preparation time by teachers, which may cause reluctance. Teachers would also need an interface available to them (possibly on their Mac Station) that would allow them to provide new questions and change the answers.

One example could use 100 words on a given topic, each attached to an RFID tag. The teacher could enter the sentence: “The capital city of Canada is Ottawa.” The program would recognize that there are seven words that make up the correct combination, and she could either make a note that there is also an obvious second version to the right answer: Ottawa is the capital city of Canada. Another possibility is that the program will only be concerned if ‘Ottawa’ is chosen, and will leave it up to the children to develop a sentence that makes sense to the group.

Another application for the train could be a progress tracker, for children following along the teacher’s lesson while building the train. For individual students, there will be less pressure to perform in front of the teacher, and the ability for children to help and talk to each other and explain themselves in their own words. The necessity for a teacher to observe and correct is not as important, and their time may be better spent preparing for constructive activities for the children to engage in.

Other suggestions could be to travel across a map of the studied topic to put information in context, offer exploratory activities such as ‘find X’ or where did the character travel to?’ and include lights and sounds as hints.

10.5 Montessori perspective

I explained my project idea to a Montessori preschool teacher and asked if she had any suggestions for the sentence train activity. She explained that if it were from the Montessori’s perspective; it would
need more obvious ‘control of error,’ such as: If the sentence doesn’t make sense, then the train shouldn’t work (move) or the pieces wouldn’t fit. It would probably also be more emphasized as an individual activity. I can also see it being effective to mirror their method of teaching sentence building by using symbols with colours and textures, as well as increased complexity by removing one safety net, or a set of clues as children become more competent in the activity.

10.6 Final thoughts

I found this research project to be fun and I’m quite pleased overall with the process and development of the prototype of the Tangible Sentence Train. Initially, I thought that my potential prototype would be an answer to a problem, and in turn it has actually offered more questions and possibilities for conversations than what I had expected.

Early on I decided to choose a topic and problem area that I felt was meaningful to me and I believe it was a worthwhile decision. Six years of teaching digital summer camps with all sorts of children and watching how they learn new tools has been inspiring to me and also helped solidify that ‘learning by doing’ something enjoyable is really the best way to learn. The research relationship with the students of Hyland Elementary has been an enjoyable one, and being able to prototype a simple RFID tag system I felt was a feat in itself.

I have been very fortunate to have been surrounded with supportive and insightful people that have made this project possible. I hope to continue working with tangible computing for children in the future.
Appendix

A. Technology, Why RFID? and Code
B. Permission Forms
C. Bibliography
D. Movie files on DVD: Game Exploration/Train Use by the Children

A. Technology

Figure 30 left: The train pulling the cars with the RFID tags, to the bottom the light indicators. Figure 31 right: Diagram (Erik Sjodin 2009) of the Arduino board being wired to the RFID reader.

My main source of instruction was from the Arduino reference site (Arduino.cc), with also important programming assistance from friends Brian Quan, João Borralho and Dan Hall. As I have only been involved with a few Arduino projects, I was intent on understanding and completing as much of my project as I could on my own, which meant that the wiring connections, devices and programming are very simple and could easily be improved by a more technical person.

Why RFID?

I was intent on using my Arduino board to build some prototypes, as I was already somewhat aware of its capabilities (from other tangible projects) and had some of the technology and resources available to me. I researched the easiest way I could use RFID for an interactive toy, and thought that it would come down to either touch sensors (but working with children there would be the opportunity for this to ‘break’
if the purpose is to touch, and RFID which would allow me to tag devices and could make it further useful for anyone choosing to create a larger database. By looking at projects like Hosokawa’s (2008) interior design project, it was inspiring to see how RFID pieces (representing wall, floor, furniture pieces etc) could help to map out information and a space for the users.

Technology Part Chart
The following parts are what I used in the prototyping of my Tangible Sentence Train.

<table>
<thead>
<tr>
<th>Technology used:</th>
<th>Non-technical parts used:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Arduino Diecimila</td>
<td>2 wooden trains</td>
</tr>
<tr>
<td>1 Parallax RFID reader</td>
<td>1 magnetic Brio train</td>
</tr>
<tr>
<td>10 RFID Tags (2 which died)</td>
<td>1 Improvised cardboard bridge</td>
</tr>
<tr>
<td>1 Piezo speaker</td>
<td>1 wooden bridge</td>
</tr>
<tr>
<td>7 Green LEDs</td>
<td>1 ‘station’</td>
</tr>
<tr>
<td>1 Red LED</td>
<td>Several blocks and character figurines</td>
</tr>
<tr>
<td>1 laptop (to do computing and sound play back)</td>
<td>However given my time, budget and programming experience constraints, I used my laptop to play back the recorded sentences and power the Arduino board.</td>
</tr>
</tbody>
</table>

Arduino/ Pure Data Processing Code:
Below is the code for the Parallax RFID Reader and Tags. As I have mentioned above, I have used the Arduino.cc extensively (RFID/Melody play) and also Erik Sjodin’s website (RFID) for coding reference and have also been mainly assisted by Brian Quan, a student from Simon Fraser University.

```cpp
#define c 3830 // 261 Hz
#define d 3400 // 294 Hz
#define e 3038 // 329 Hz
#define f 2864 // 349 Hz
#define g 2550 // 392 Hz
#define a 2272 // 440 Hz
#define b 2028 // 493 Hz
#define C 1912 // 523 Hz
#define R 0 // Define a special note, ‘R’, to represent a rest

int speakerOut = 10; // Piezo speaker
int melody[] = { C, b, g, C, b, e, R, C, c, g, a, C};
int beats[] = { 16, 16, 16, 8, 8, 16, 16, 16, 16, 16, 16, 8, 8};
int MAX_COUNT = sizeof(melody) / 2;
// Melody length, for looping.

long tempo = 10000;
int pause = 1000; // Set length of pause between notes
int rest_count = 100; // Loop variable to increase Rest length
int tone = 0;
int beat = 0;
long duration = 0;

#define unsigned String
int val = 0;
char code[10];
int bytesRead = 0;
int count = 0;

char* Noun1 = "0415B02A18";
char* Noun2 = "0415E9ED5E";
char* Noun3 = "0415AF7329";
char* Noun4 = "0415D7C799";
char* Noun5 = "0415E9FCAC";
char* Noun6 = "0415D7B445";
char* Noun7 = "0415DA3746";

boolean word1 = false;
boolean word2 = false;
boolean word3 = false;
boolean word4 = false;
boolean word5 = false;
boolean word6 = false;
boolean word7 = false;

int ledPin4= 4;
int ledPin5= 5;
int ledPin6= 6;
```
int ledPin7 = 7;
int ledPin8 = 8;
int ledPin9 = 9;
int ledPin11 = 11;
int ledRed12 = 12;

void setup() {
    Serial.begin(2400);  // RFID reader SOUT pin connected to Serial RX pin at 2400bps
    pinMode(2, OUTPUT);  // Set pin 2 as OUTPUT to connect it to the RFID /ENABLE pin
    digitalWrite(2, LOW);  // initialise the reader with a reset cycle
    delay(100);
    digitalWrite(2, HIGH);
    delay(100);
    digitalWrite(2, LOW);
    delay(100);
    pinMode(ledPin4, OUTPUT);
    pinMode(ledPin5, OUTPUT);
    pinMode(ledPin6, OUTPUT);
    pinMode(ledPin7, OUTPUT);
    pinMode(ledPin8, OUTPUT);
    pinMode(ledPin9, OUTPUT);
    pinMode(ledPin11, OUTPUT);
    pinMode(ledRed12, OUTPUT);
    pinMode(speakerOut, OUTPUT);
}

void playTone() {
    long elapsed_time = 0;
    if (tone > 0) {  // if this isn’t a Rest beat, while the tone has
        while (elapsed_time < duration) {  // played less long than ‘duration’
            digitalWrite(speakerOut, HIGH);
            delayMicroseconds(tone / 2);
            digitalWrite(speakerOut, LOW);
            delayMicroseconds(tone / 2);
            elapsed_time += (tone);  // Keep track of how long we pulsed
        }
    } else {  // Rest beat; loop times delay
        for (int j = 0; j < rest_count; j++) {  // See NOTE on rest_count
            delayMicroseconds(duration);
        }
    }
}

void loop() {
    digitalWrite(2, LOW);  // activate reader
    if (Serial.available() > 0) {  // if data available from reader
        if ((val = Serial.read()) == 10) {  // check for header
            bytesRead = 0;
            while (bytesRead < 10) {  // read 10 digit code
                if (Serial.available() > 0) {
                    val = Serial.read();
                    if ((val == 10) || (val == 13)) {
                        // if header or stop bytes before the 10 digit reading
                        break;  // stop reading
                    }
                }
            }
        }
    }
}
```c
/*
 *  code[bytesread] = val;  // add the digit
 *  bytesread++;          // ready to read next digit
 */

digitalWrite(2, HIGH);
if(bytesread == 10 ) {  // if 10 digit read is complete
    Serial.println(code);  // print the TAG code
    bytesread = 0;
}
//reset bytesread so this section doesn't repeat next time
if(compareStrings(code, Noun1)){
    Serial.println("Noun1");
    digitalWrite(ledPin4, HIGH);  // turn LED ON//
    digitalWrite(ledPin5, LOW);
    digitalWrite(ledPin6, LOW);
    digitalWrite(ledPin7, LOW);
    digitalWrite(ledPin8, LOW);
    digitalWrite(ledPin9, LOW);
    digitalWrite(ledPin11, LOW);
    digitalWrite(ledRed12, LOW);
    word1=true;
    word2=false;
    word3=false;
    word4=false;
    word5=false;
    word6=false;
    word7=false;
} else
  if(compareStrings(code, Noun2) && word1){
    Serial.println("Noun2");
    digitalWrite(ledPin5, HIGH);  // turn LED ON//
    digitalWrite(ledPin6, LOW);
    digitalWrite(ledPin12, LOW);
    word2=true;
  } else if(compareStrings(code, Noun3) && word2){
    Serial.println("Noun3");
    digitalWrite(ledPin6, HIGH);  // turn LED ON//
    digitalWrite(ledPin12, LOW);
    word3=true;
  } else if(compareStrings(code, Noun4) && word3){
    Serial.println("Noun4");
    digitalWrite(ledPin7, HIGH);  // turn LED ON//
    digitalWrite(ledPin12, LOW);
    word4=true;
  } else if(compareStrings(code, Noun5) && word4){
    Serial.println("Noun5");
    digitalWrite(ledPin8, HIGH);  // turn LED ON//
    digitalWrite(ledPin12, LOW);
    word5=true;
  } else if(compareStrings(code, Noun6) && word5){
    Serial.println("Noun6");
    digitalWrite(ledPin9, HIGH);  // turn LED ON//
    digitalWrite(ledPin12, LOW);
```
word6=true;
}
else if (compareStrings(code, Noun7) && word6){
    Serial.println("Noun7");
    digitalWrite(ledPin11, HIGH);
    digitalWrite(ledRed12, LOW);
    for (int i=0; i<MAX_COUNT; i++) {
        // Set up a counter to pull from melody[] and beats[]
        tone = melody[i];
        beat = beats[i];
        duration = beat * tempo; // Set up timing
        playTone();
    }
}
else{
    digitalWrite(ledRed12, HIGH);
}
Serial.flush();
}
}
}
}

boolean compareStrings(char string1[10], char string2[10]) {
    int index=0;
    while(index < 10) {
        if(string1[index]!=string2[index]) {
            return false;
            index=11;
        }
        index++;
    }
    return true;
}
September 26, 2008

Amanda Hall
15767 106th Avenue
Surrey, BC V4N 1K5

Dear Amanda,

Re: "Digital Learning Toy"

Please use this letter as confirmation of acceptance of your research project in principle. As you know, district level endorsement does not imply commitment of individual schools, students or other participants and you are required to seek consent, sequentially of those involved.

I wish you every success with your research and remind you that a final report is to be submitted to this department on completion.

Yours truly,

Dr. Sharon Cohen
Assistant Superintendent
Research & Evaluation
SC/jvm

Permission letter to work in Surrey schools
Parent permission form for the Learning Toy Project

My child **Brittany Sarah Krizmanich** has permission to participate in the project.

Yes [ ] No [ ]

I give permission for photos and/or video of my child to be used for educational and research purposes.

Yes [ ] No [ ]

Parent Signature: [Signature] Date: Nov 27, 2008

Please return completed form to Ms. Bryden or Mrs. Willis. Thank you very much for your support.

---

Parent permission form for the Learning Toy Project

My child **Abhir** has permission to participate in the project.

Yes [ ] No [ ]

I give permission for photos and/or video of my child to be used for educational and research purposes.

Yes [ ] No [ ]

Parent Signature: [Signature] Date: Nov 27, 2008

Please return completed form to Ms. Bryden or Mrs. Willis. Thank you very much for your support.

---

Parent permission form for the Learning Toy Project

My child **Colin Archer** has permission to participate in the project.

Yes [ ] No [ ]

I give permission for photos and/or video of my child to be used for educational and research purposes.

Yes [ ] No [ ]

Parent Signature: [Signature] Date: Nov 26, 2008

Please return completed form to Ms. Bryden or Mrs. Willis. Thank you very much for your support.
Copies of Permission Forms ---- Hyland Elementary Students

Parent permission form for the Learning Toy Project

My child Ticha Kung has permission to participate in the project.

Yes [ ] No [x]

I give permission for photos and/or video of my child to be used for educational and research purposes.

Yes [x] No [ ]

Parent Signature: [Signature] Date: Nov. 27, 2008

Please return completed form to Ms. Bryden or Mrs. Willis. Thank you very much for your support.

Parent permission form for the Learning Toy Project

My child Kristen Pern has permission to participate in the project.

Yes [x] No [ ]

I give permission for photos and/or video of my child to be used for educational and research purposes.

Yes [x] No [ ]

Parent Signature: [Signature] Date: November 27, 2008

Please return completed form to Ms. Bryden or Mrs. Willis. Thank you very much for your support.

Parent permission form for the Learning Toy Project

My child Myranda Kaiser has permission to participate in the project.

Yes [x] No [ ]

I give permission for photos and/or video of my child to be used for educational and research purposes.

Yes [x] No [ ]

Parent Signature: [Signature] Date: 11/27/08

Please return completed form to Ms. Bryden or Mrs. Willis. Thank you very much for your support.

Parent permission form for the Learning Toy Project

My child Cameron Headman has permission to participate in the project.

Yes [x] No [ ]

I give permission for photos and/or video of my child to be used for educational and research purposes.

Yes [x] No [ ]

Parent Signature: [Signature] Date: Nov. 26, 2008

Please return completed form to Ms. Bryden or Mrs. Willis. Thank you very much for your support.
List of References


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