TEACHING TABLE

a tangible mentor for pre-kindergarten math education

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abstract

In the present day, the *adoption of technology* in educational practices, specifically those focused on early age education, is increasingly being seen as a major step forward in making the education 'modernized'. Unfortunately this adoption has just been limited to bringing the 'computer to the classroom' and making the students learn how to use it. Such a step has been consequently fraught with controversies, and not without reason - research over the years has shown that a child's active engagement with *physical objects* is essential for laying the foundation for intelligence and abstract thought in the young mind of pre-school aged children – thus the movement towards *virtual interfaces* cannot entirely be justified. What is to be realized is, that the full potential of technological tools will only be achieved when they are used effectively and in ways that are meaningful and appropriate to support physical abilities and critical thinking of children.

In this project, I explore how to keep the interaction and learning for the pre-K students *in the real world* using physical objects while harnessing the power of the virtual one using Tangible Computing. In that attempt, I present here the design and implementation of "Teaching Table" – a system of digital manipulatives and display surface embedded with sensing technology and linked to computational intelligence. The table can track tagged objects placed on its surface, accurately identifying their type and location while providing a coincident visual display and audio feedback, using which activities are created that impart math knowledge to the children playing on the table. I also propose how the table can be an integral addition to the present classroom environment as it can enhance learning experiences of children in an interactive and playful way by involving them in physical activities. Focusing on the age group of pre-kindergarten children, the Teaching Table activities will attempt to develop fundamental math skills by leveraging the already existing curriculum guidelines for pre-K schools set by the State of Georgia (or, any other state as appropriate).

This document includes detailed rationale behind standpoint of the project, a survey of related topics & works and a description of the approach, methodology, and implementation of the Teaching Table.

introduction

> "Play is often talked about as if it were a relief from serious learning. But for children, play is serious learning. Play is really the work of childhood."
> -Fred Rogers

It is through play that much of children's early learning is achieved. The physical, emotional and intellectual development of young children is dependent upon active engagement - touching, manipulating, exploring and testing the world around them [1, 2]. Traditionally, physical objects and 'manipulatives' have been used in kindergartens, elementary schools and elsewhere to engage and help children learn in an effective and meaningful manner through hands-on play activity. Educational toys that provide hands-on and constructive learning have gained immense popularity in academic and commercial circles because of their value in childhood learning.

In my present exploration, I begin by seeking a satisfactory answer to the question: *How can I improve the effectiveness of present educational experiences using physical/digital manipulatives for pre-Kindergarten students?*

A look at the tools currently employed for pre-K learning provides a way. The limitations of traditional toy-media in providing interactivity during teaching can inhibit the process of imparting knowledge. In the course of explorations for adding interactivity to the learning experience, newer ways of using technology are being investigated by researchers. The computer as an educational medium is being explored in many schools to impart interactivity and augment learning. But the ability to use computer interfaces by very young users, with limited literacy and developing motor and cognitive skills, is often a major hurdle in learning. There has been a growing body of research relating in studying hardware and software interface issues relating to children [5, 6, 7].

Piaget and other developmental psychologists have emphasized the importance of using physical objects for young children's cognitive development [3, 4]. In that respect, researches in other forms of interaction with computers have made promising advances in redefining how toys can be used for both play and learning. Broadly categorized as 'tangible interfaces', these advances in computational and sensing technologies have greatly impacted the field of educational technology. Tangible interfaces are ways of interacting with a computer that use real objects that are relevant to the task as input devices, instead of a keyboard or mouse [8, 9]. These technologies are providing a basis for more innovative, accessible and cheaper ways of disseminating knowledge, and coupled with novel improvements in personalized interactivity, can help overall development of a child's mind. Their application is thus being increasingly acknowledged as both plausible and essential for education at young ages.

In this design document I describe the Teaching Table - an interactive tabletop audio-visual device aimed at enhancing the learning experience for pre-kindergarten children by involving them in physical activities. The table can track tagged objects placed on its surface, accurately identifying their type and location while providing a coincident visual display and audio feedback, and educational activities have been developed around this setup to teach fundamentals of math to pre-K children.

The Teaching Table, in addition to capitalizing on the familiar advantages of Tangible Computing in education technology for enhanced teaching, also includes the adoption-relevant functionalities that any new form of technology should possess to be used in real-world situations. Teaching Table primarily incorporates these functionalities in two forms:

1. Play Activities – These are pre-defined interactive games that the children play to understand individual aspects of the subject. By keeping the activities aligned to the State educational curriculum guidelines [Appendix-I], the Teaching Table has been designed to be easily incorporated into the current pre-K curriculum and hence the classroom. The option of user-customizable activities has also been planned for future versions of Teaching Table.
2. Assessment Tools – The table also includes assessment tools for teachers to record and retrieve the performance data relating to each student using various parameters. This tool will greatly help in evaluation tasks of the pre-K teacher.

Additionally, the simple, robust, and economical technology will hopefully serve as an incentive for adoption of the Teaching Table in the present-day classrooms.

premise of the project

The premise for this project has been laid by developments in different fields, to which the subject of the project is closely related:

1. CHILDREN'S EDUCATION AND TECHNOLOGY PERSPECTIVE

The importance of sensory physical experience for learning has been long established by education theorists. Jean Piaget in his 'Theory of Intellectual Development' explains that the learning process in very young children begins by processing information coming into the brain through firsthand experiences with things, people, and feelings, depending entirely on the senses of vision, hearing, touch, smell, and taste [3]. The brain continually assimilates, or digests, information. Later in the development cycle, children's brains become able to form mental pictures or symbols of things, people, and feelings. They then begin to change their existing knowledge to form new ideas. However, for several more years children continue to depend to a large degree on their senses and firsthand experiences for learning. Piaget pictured adaptation as a basically upward spiral through a series of stages and sub-stages, making possible higher and higher levels of learning [4, 31].

> "Children's experiences before kindergarten can help build a solid foundation for future learning. The reality is that learning does not begin when kids are age 5. Learning begins well before they enter the schoolhouse."
>
> – Sharon Lynn Kagan (professor, Teacher's college, Columbia University)

Traditional toys have supported this concept of educational theorists by providing physical means to learn and play, enabling children to explore abstract and tangible concepts through direct manipulation of physical objects. In recent years, with the developments in educational technology, new ways to incorporate technology into the learning experience are being explored and introduced [30]. This adoption has a twofold implication – it enhances the learning and development process and it makes the child more comfortable with using technology [10]. Most notably the 'computer' is hailed to be a major, positive impact on children's social, emotional, language, and cognitive development [11, 12].

The attempts to adopt technology in early childhood education, however, have not been devoid of controversy. What is to be realized is, that the full potential of technological tools will only be achieved when they are used effectively and in ways that are meaningful and appropriate to support physical abilities and critical thinking of children [13]. The use of the computer in its present form for the education of young children lies contrary to the ideal development process described by Piaget, who theorized that a child's active engagement with physical objects is essential for laying the foundation for intelligence and abstract thought in the young mind.

Additionally, for very young users who can't read or write and have still-developing motor and cognitive abilities learning and using computer interfaces is a major impediment. Preschool and even young elementary school children are still not at a literacy level required to read and understand screen/menu text and type their responses on the keyboard, nor do they have the motor skills required to operate a mouse or any standard point-and-click device [14]. Research shows that this inability is due to a variety of developmental factors - including the lack of fine motor control needed to use existing pointing devices, the lack of cognitive understanding of the mapping between controller use and what's happening on screen, and the lack of abstract thinking skills - necessary to understand the typical screen-based representation of concepts [5,6,7]

As a result, there has been a growing interest in a new generation of interfaces that allow interaction with computers using physical objects. Of these, the most relevant ones to the topic here are computationally-enhanced physical objects or manipulative materials called "digital manipulatives" [20]. A detailed discussion of the types and characteristics of these digital manipulatives is provided in the next section.

2. TANGIBLE COMPUTING RESEARCH

There has been a growing body of research into approaches for linking the physical and digital worlds. Weiser's vision of ubiquitous computing [15], which proposes that our computer interactions should be more tightly integrated with our real-world activities, has made a seminal impact on the research in the field. Notable areas include ubiquitous computing, augmented reality, and computer-augmented environments, which have spurred continuing research efforts throughout the 1990s. Simultaneously, a new stream of interface research has begun to explore the relationship between physical representation and digital information, highlighting kinds of interaction that are not readily described by existing frameworks. Fitzmaurice, Ishii, and Buxton took an important step towards describing a new conceptual framework with their discussion of "graspable user interfaces" [16]. Building upon this foundation, Ishii and Ullmer extended these ideas and proposed the term "tangible user interfaces" (TUIs) [8].

Ullmer identifies three high level approaches to building tangible computing interfaces: interactive surfaces, constructive assemblies, and tokens+constraints [17]. Phenomenal research work is going on in all the three approaches, and most relevant ones to the subject are defined below:

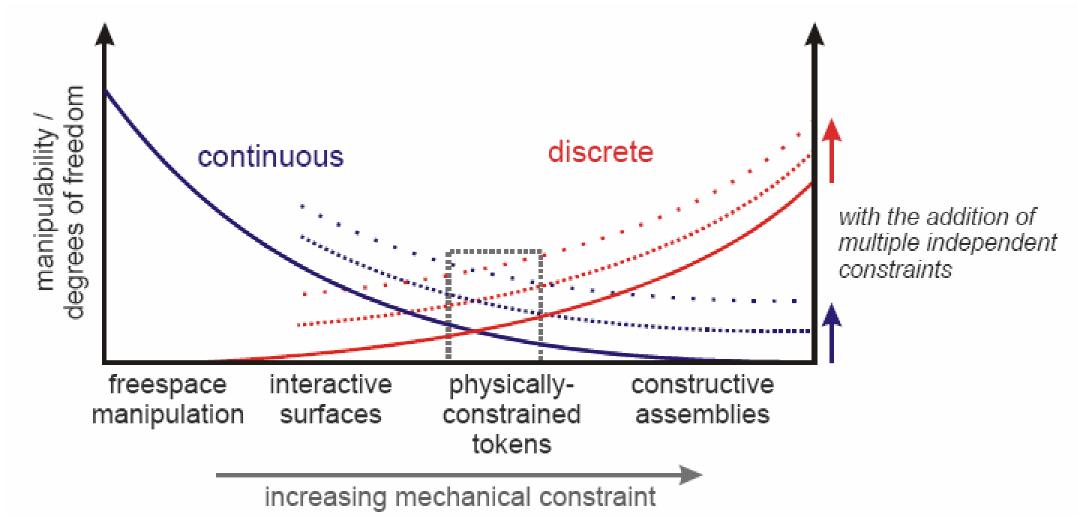


Figure 1: Relationship between continuous and discrete manipulability within tangible interfaces [17]

a. Interactive surfaces

A popular paradigm for tangible interfaces is based upon the concept of "interactive surfaces," where physical objects are manipulated by users upon an augmented surface. The presence, identity, and configuration of these objects is then electronically tracked, computationally interpreted, and graphically mediated. In the context of tangible interfaces, interactive surfaces have most frequently taken one of several major forms. Perhaps the most popular are "interactive workbenches," where objects are configured upon a near-horizontal workbench. A number of tangible interfaces have also been based upon "interactive walls", having interaction based on a vertical augmented surface [17].

Some good examples of interactive surfaces within our context are the commercial products of Zowie Intertainment. Zowie marketed two different playsets that used physical tokens to represent characters and artifacts (Figure 2). The placement and reconfiguration of these tokens within the playset was used to navigate and interact with various scenarios that were animated upon the screen [18].

Figure 2: Interactive surfaces in Zowie Intertainment products

b. Constructive assemblies

Another major approach for tangible interfaces draws inspiration from building blocks and LEGO™. This approach has been employed by some of the earliest tangible interfaces, often toward the ends of providing modular, electronically instrumented artifacts for constructing models of physical-world systems [17].

The concept of constructive assemblies has been used in many cases to build interactive educational toys – mostly representing an enhanced form of LEGO™. Notable examples for constructive assemblies include the Stackables of Kramer and Minar [19]; the Tiles of Kramer [21]; and Heaton's Peano [22]. Each of these interfaces developed additional novel features, such as the Stackables' concept of a distributed display; the Tiles' use of mobile code; and Peano's conception as a touch-sensitive, painterly medium (Figure 3).

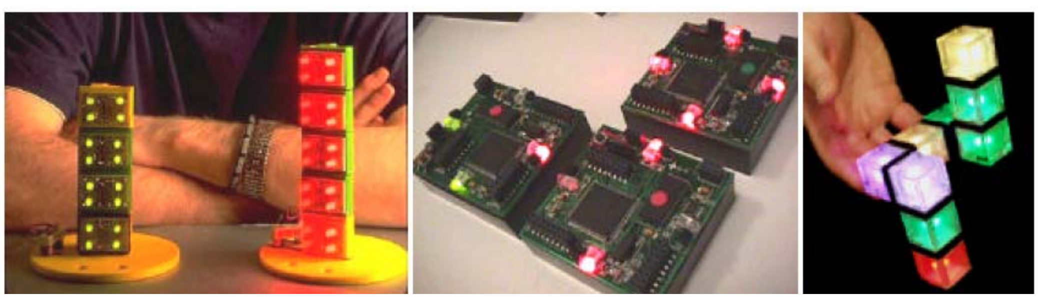


Figure 3: Stackables, Tiles and Peano

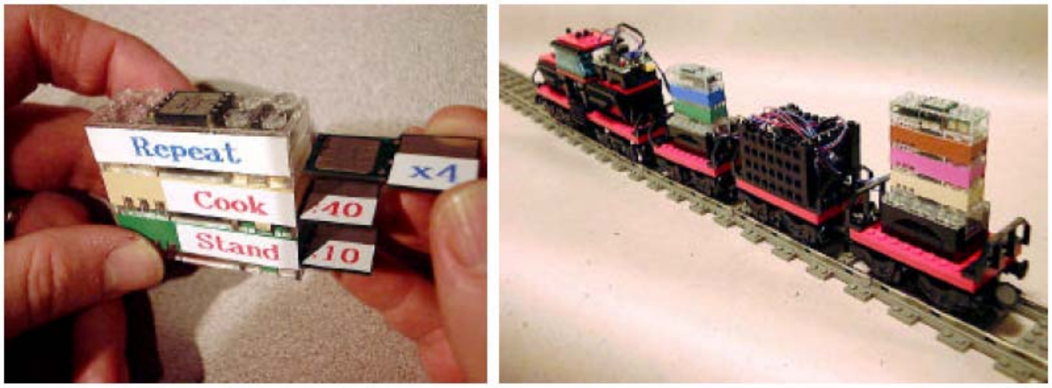


Figure 4: Another example of constructive assemblies:
Tangible Programming Bricks and a train carrying "tangible rules" [23]

c. Token+constraints

Ullmer identified a new TUI approach called "tokens+constraints" (or "physically constrained tokens") [17]. In this approach, physical tokens are used to describe and represent aggregates of digital information, allowing a small number of these tokens to manipulate large collections of digital information. Ullmer describes tokens as "discrete, spatially reconfigurable physical artifacts that each describe or represent an element or aggregate of digital information", and constraints as "structures that physically channel how tokens can be manipulated, often limiting their movement to a single physical dimension". Interaction methods are for such a computational system is defined by analogical mapping of physical manipulation of tokens within these constraints.

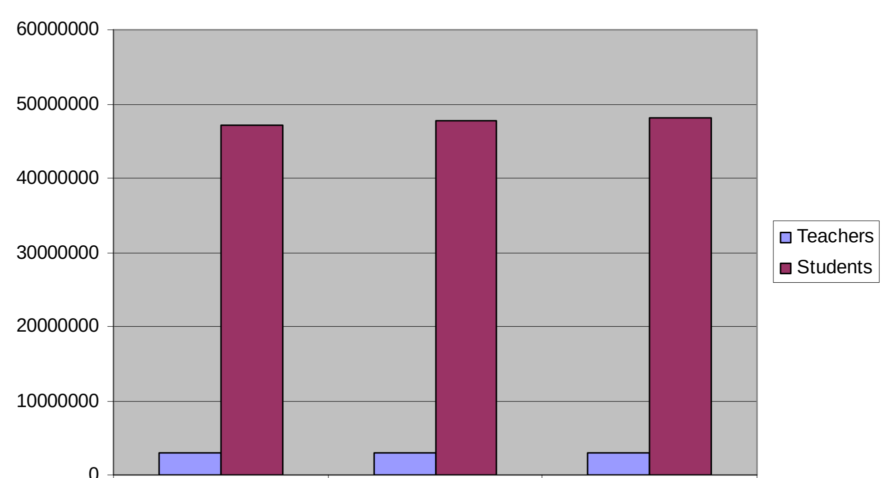
An example of physically constrained token system is the TUI for manipulating audio content in the "Music Blocks" system, which (along with Zowie's playset products) was one of the first tangible interfaces to be commercially marketed [24]. This system binds different musical fragments to the faces of physical cubes, mapped as a function of the color of the blocks and the shapes on their sides (Figure 5). Blocks can be sequenced within several consecutive receptacles, and new music mappings can be exchanged with Wintel computers via a "Cyber Cartridge" memory module.

Figure 5: Neurosmith Music Blocks [24]

3. OTHER DEVELOPMENTS IN THE FIELD:
(Scarcity of Pre-K teachers; Renewed interest in Pre-K education quality standards)

The main adopters and evaluators of educational toys for very young children have been day care centers and pre-K schools, so it would be useful to observe recent developments in this field of interest to us.

The first among these is the concern regarding the supply of pre-K teachers not being able to keep up with the demand [25]. The NAEYC in its 'Accreditation Performance Criteria' proposes that an ideal teacher-student ratio for pre-schoolers in a group larger than 20 be 1:10 [26]. A look at the statistics however presents a very different picture – a ratio of almost 1:16, with the ratio worsening every year [27]:



	1999	2000	2001
Teachers	3000000	2997741	3034054
Students	47200000	47687871	48202324

Figure 6:
A comparison of the number of pre-K teachers and students from 1999-2001 (Data Source: Education Week Research Center) [27]

This phenomenon has raised concerns in the education field and elsewhere. The reasons attributed to it are many – from insufficient compensation to high attrition rate. The researchers in educational technology should hence take cue and put emphasis on learning tools for children to be also assistive tools for teachers, in order to be effectively accepted in the school environment. This is one of the central goals of 'Teaching Table' that distinguishes it from other related teaching technology and digital manipulative projects.

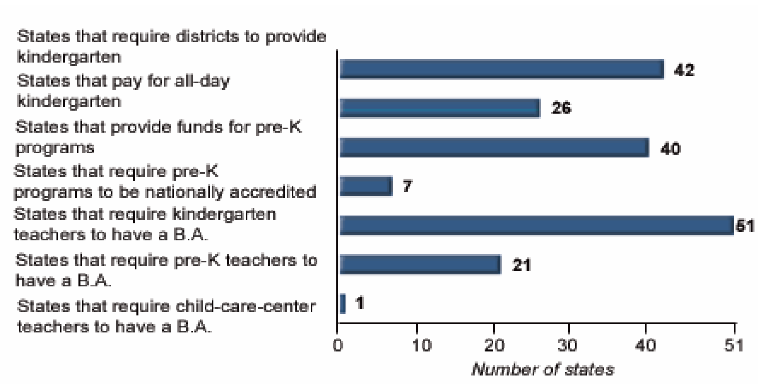
Coupled with the growing concern over constricted supply of pre-K teachers, state governments over the nation have increased their efforts to provide access to early childhood education for preschool-age children [28].

Vital Statistics on US Public Schools	
Total schools: 89,599	**Percent minority students:** 37.7 percent (17.7 million)
Number of teachers 3 million	**Percent children in poverty** 18.7 percent (13.3 million)
Total pre-K12 enrollment 47.2 million	**Percent student with disabilities** 12.4 percent (5.8 million)
Annual pre-K12 expenditures $334 billion	**Children under 5** 19.2 million

Figure 7: Vital Statistics on US Public Schools *(Source: Education Week)*

As the impact of early learning experiences on the personality and abilities of the grown individual are being realized, there has been national emphasis on pre-K programs with effective teaching practices and a challenging and appropriate curriculum. Pre-kindergarten programs that support effective teaching practices have been shown to lead to important growth in children's intellectual and social development, which is critical to their future academic success [2]. Emphasis on bringing technology to classrooms has also increased, and the efforts are being appreciated to a large extent [29]. Quality programs that provide a challenging but achievable curriculum have been shown to engage children in thinking, reasoning, and communicating with others.

The school readiness goals of the Pre-K program provide appropriate preschool experiences emphasizing growth in language and literacy, math concepts, science, social studies, arts, health and physical development, and social and emotional competence. Several efforts are under way to rethink how the United States pays for early care and education, and many states are seeking new sources of money to support their effort. Promising endeavors are being made by several state governments in this respect [32].



- In 1998, California voters approved a 50-cent tax on cigarettes and other tobacco products to help support early-childhood initiatives.
- Arkansas recently enacted a new surcharge on beer that is earmarked for child care.
- Georgia's pre-kindergarten program is financed through state lottery proceeds.
- In New Jersey and North Carolina, state courts have ordered more spending on early-childhood services for disadvantaged youngsters as part of settlements in school finance cases.

Figure 8: Growing concerns for Pre-K education among US States
(Source: Education Week)

1. COMPUTATIONALLY ENHANCED LEARNING TOYS/DEVICES

There have been a host of innovative researches in the development of educational Tangible User Interfaces (TUIs) for children, a selection is mentioned below:

- **TICLE** – Tangible Interfaces for Collaborative Learning Environments (TICLE), a computer-vision system that tracks children's play with the Chinese geometry puzzle Tangram. The system scaffolds the play process with hints in real-time. TICLE focuses on 'scaffolding' (which is a technique of iteratively revealing more helpful hints to the child about the task as a part of the play), the play process with the Tangram puzzle, and in the same way, could scaffold children's play with other manipulatives [33].

Figure 9: TICLE at the Goudreau Museum of Mathematics in Art and Science

- **Bitball** - [34] A programmable ball that uses its internal acceleration sensor to map data in real-time to different mediums, such as sound and light. Children can themselves change the BitBall programs to customize the mapping and hence can learn about the abstract concept of acceleration in a playful way. Resnick [35] reports that a group of university students could not apply their physics classroom knowledge to a real-world context: finding the top of a ball's trajectory based on its acceleration data alone. Using the BitBall they learned that this is in fact impossible to do.

Figure 10: The Bitball – a ball with a tiny 'cricket' computer embedded inside it.

- **Beads** - are programmable electronic beads that engage children in creating "one dimensional" dynamic light patterns [35]. Beads focus on the creation of necklaces, and the beads' internal

Figure 11: A Bead Necklace – each bead is ½ inch in size

operations do not represent a specific mathematical operation, but were rather designed to make it easier to create engaging light patterns.

- **Block Jam** – [36] is a block interface for interactive music creation. Block Jam developers define it as a Modular Tangible Interface that is "Functionally Homogeneous" vs. "Functionally Heterogeneous" - meaning there is one type of physical artifact with a single function rather than different physical artifacts each holding a different function. Block Jam was not designed to help people understand what the building blocks of a musical sequence are, but was rather designed to make it easier to construct a musical sequence in an expressive process.

Figure 12: Tangible Music blocks - the different colors indicate the different sound groups

- **Topobo** – Topobo [37] is a 3D constructive assembly system embedded with kinetic memory, enabling people to record and playback physical motion. By snapping together a combination of Passive (static) and Active (motorized) components, people can quickly assemble dynamic forms like animals and skeletons. Pushing, pulling, twisting, and stretching the components can animate those forms. For example, a dog can be constructed and then taught to gesture and walk by twisting its body and legs. The dog will then repeat those movements and walk repeatedly. Topobo can help children gain better understanding of balance, center of mass, coordination, relative motion, and multiple degrees of freedom. BACKPACK is a recent implementation of Topobo blocks that also include the concept of "record and play" for effective constructivist learning [41].

Figure 13: An animal creation made up of Topobo components (in different color)

- **Electronic Duplo Blocks** – Aimed at preschoolers, the Electronic Blocks [38] are tangible programming elements mounted inside LEGO Duplo blocks. Using sensor, logic, and action blocks young children create interactive devices such as a light block that activates when clapping or a motion block that moves when light is detected. The Electronics Blocks strength is in its simplicity, enabling very young children to independently create different devices and in the process explore core concepts of logic and programming. Wyeth [38] reports that older children (elementary and middle school students) could build more sophisticated creations, such as towers of blocks that "talked" to each other, alarm clocks and cars that could count.

Figure 14: A LEGO duplo block system, with its components disassembled

- **ActiveCube** – a cube-based interface allowing users to build 3D structures in the real world while computer software automatically generates a corresponding 3D virtual model that is displayed on the computer screen [39]. In addition, the computer retrieves similar shapes from its 3D models database, such as an airplane, house, or car. ActiveCube encourages design and construction of real world objects.

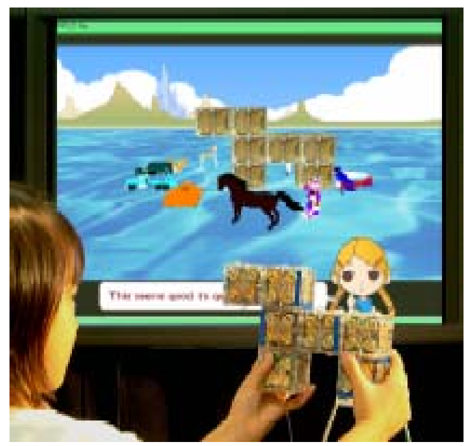


Figure 15: ActiveCube in action - Shape selection from several candidates

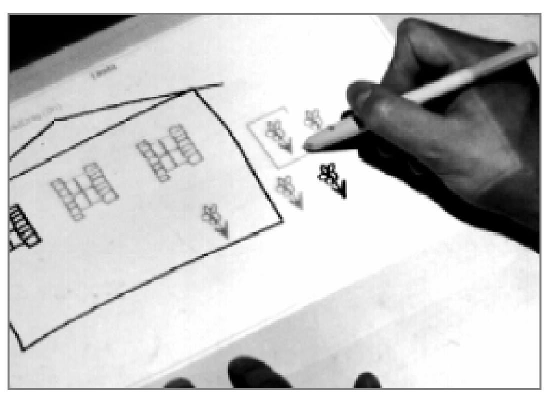
- **Wireless Generation** – In the area of assessment devices, Wireless Generation has a variety of commercial products to facilitate school teachers in real-time recording and assessment of a child's performance. Most of the devices also have in-built sample tests, which can be customized by the teacher to meet individual needs. The testing and assessment applications are run on a handheld device, which can be carried around the classroom.

Figure 15: Wireless Generation assessment systems in use in classrooms

2. INTERACTIVETABLE SYSTEMS & FRAMEWORKS

In the past decade, there have been an increasing number of research efforts to develop various kinds of Interactive (multimedia) table systems and their underlying technologies. Interactive Table systems, also known as interactive display surfaces or tangible table-tops, are surfaces upon which the spatial configuration of tagged objects is computationally interpreted and then augmented with coincident (front or rear projected) visual output [41]. The tagged objects can take on a form that is representative of their digital functionality, facilitating the off-loading of some of the information within the interactive environment from a purely graphical form to a physical-world representation [44]. Following are some examples of research projects going on in the area of interactive table systems, also representing different technologies used in object detection and identification:

- **TViews** – The TViews [41, 42] is a media interaction platform designed for shared living spaces within everyday social environments such as homes, classrooms and public space. It is an extensible method and acoustic-based sensing framework that provides a means for real-time multi-object tracking on the tabletop and for the management of large numbers of objects and applications across multiple platform instances. The objects used for tracking can be physically customized to suit particular applications, and the table provides output via a coincident embedded display. There has also been work on developing prototype applications including digital media browsing and interactive game play on the table.

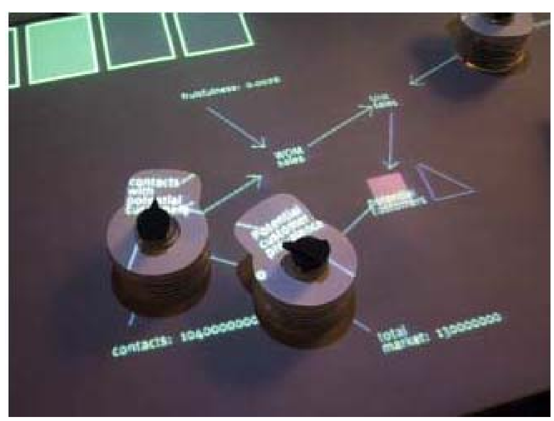


- **Digital Desk** – The Digital Desk [48] made use of an ordinary physical desk with a video camera mounted above that could track the movements of an LED tipped pen to determine where the user was pointing. Later versions included more advanced technologies like document identification capability based on OCR, and overhead digital projection of electronic objects onto regular paper documents.

- **metaDESK** – The metaDESK [45] system uses graspable handles for manipulating digital objects directly using two tethered trackers. The system demonstrates the use of "phicons," or physical icons, in the context of an interactive surface. An infrared camera inside a table tracks these phicons using simple computer vision techniques. Output from the system projects onto the same space using rear video projection

- **DiamondTouch** – The MERL DiamondTouch [46] table, now available commercially as a developer's kit, is a multi-user touch technology for tabletop front-projected displays. It enables several different people to use the same touch-surface simultaneously without interfering with each other, or being affected by foreign objects, thus facilitating small group collaborations. This is achieved by embedding an array of antennas in the touch surface that generates location dependent, modulated electric fields to detect user-touch on the surface.

- **Sensetable** – Sensetable [47] is a system that electromagnetically tracks the positions and orientations of multiple wireless objects on a tabletop display surface. Graphical representations of digital information are projected onto the tabletop sensing surface. When the user moves a puck close to one of these graphical representations, the puck becomes "bound" to that item, and physical changes to the puck, such as plugging a modifier into the socket on top, cause corresponding changes in the bound information.



conceptual approach

With the developments discussed in the section "Premise of the project," three main conclusions can be drawn that are relevant to a researcher developing interactive toys for young children:

a) Use of physical objects should be given preference in educational activities for young children. Research shows that children's active engagement with physical objects lays the foundation for intelligence and abstract thought that ensures success in their daily activities.
b) Advances in tangible computing, especially those in digital manipulatives, provide a way to combine the interactive properties of computer mediation, while avoiding the constraints of a traditional mouse, keyboard and screen interface. Physical objects also can now be embedded with computational intelligence.
c) With the growing workload on a typical pre-kindergarten teacher and push for higher quality standards, there is a major need to provide tools to the teachers that not only enhance the process of learning for the child, but also act as assessment devices for teachers – by helping to assimilate progress of students and providing feedback based upon standard curriculum practices.

As we look at these concepts in perspective, we must realize that, although the independent thoughts expressed above are not novel in themselves, the novelty lies in the attempt to integrate these concepts into a single artifact. In fact, the three concepts presented here represent the trichotomy in education circles itself. They are the concerns of the three emerging groups within education - *education theorists* representing the first, *education technologists* representing second, and *field practitioners* standing for the third concern.

The project 'Teaching Table' defines a unique position for itself by identifying the three concerns and attempting to work in concert with the philosophies of the three groups. Although there has been earlier work done in applications of tangible interfaces for educational purposes (see "Related works" section), most of them have been influenced by (a) above – making physical interactive tools. To a large extent, neither the support for standard curriculum practices nor assessment have been given due consideration.

Keeping the above points in mind, we can now derive basic attributes for the interactive Teaching Table trying to address all the issues in hand:

1. **Physicality**
2. **Interactivity, and**
3. **Support for curriculum practices & assessment**

The three foci of the project are as depicted in the following figure:

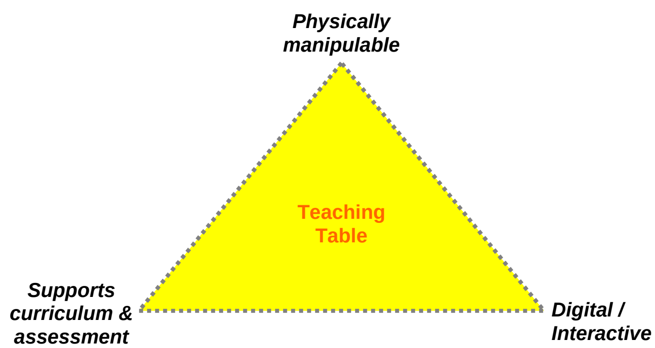


Figure 16: Proposed attributes of the learning tool

The Teaching Table addresses the attributes 1 & 2 above by building upon developments in the field of tangible computing – the ability to detect and identify physical objects using the sensing technologies, along with using these technologies as an interface to the computer can provide us a way to achieve both (1) physical manipulability and (2) digital interactivity while developing educational applications towards our aim.

To partially address the attribute 3 above, the activities that will be played on the table have been designed using the guidelines obtained from Georgia State's content standards for pre-K education. For the limited purpose of building a prototype, the current activities aim specifically at teaching math fundamentals, but they can be easily extended to cover other relevant subjects in future.

Finally, to incorporate the last issue in attribute 3, a software-based assessment tool has been included for use by pre-K teachers, using which they can access performance data related to every activity a student has played, on parameters requested by the teacher. An advanced version of the assessment tool is in works that will help teachers in high-level evaluation and grading.

The project attempts to approach a traditional problem with the solution of a new technology. There have been few and varied antecedents, and none of them focus explicitly on tying the solution to the present classroom curriculum and environment. As such, there were many discoveries to be made along the way, and the best way to move forward was an open-ended approach to learning about the domain, by:

a) Researching into similar projects and learning from their experiences,
b) Observing the present learning environment practices at actual pre-K schools, and
c) Testing the artifact developed in real classrooms and refining it.

LEARNING FROM OTHERS' SUCCESSES

From the onset, the project aimed as much at *exploring* tangible technologies and artifacts as on *delivering* an interactive system that could be used to enhance learning activities for pre-K children. In order to avoid reinventing the wheel, an integral step of the methodology involved researching relevant projects being undertaken in places elsewhere. Identification of general and specific guidelines, both in technical and interaction areas, informed many important aspects in the shaping of the present form of the Teaching Table.

For example, in order to implement the object identification system, several sensing frameworks (including ICs, RFID, and Bluetooth etc.) were explored. The final framework that was selected is based upon the research and doctoral thesis of Alexandra Mazalek (Chair) in the area of Tangible platforms [41] – an application of which is 'TViews' [42]. In its simplest form, such a tangible platform consists of 'graspable pawns' (tracked by electromagnetic [EM] sensing technology), a sensing surface, a projector/screen to augment the tangible output, and application processes running behind the scenes coordinating input and output.

Figure 17: A prototype in development for the Math Manipulative project at Sesame Workshop

The inspiration for the interaction model came from the project 'Math Manipulatives' which is currently in works at Sesame Workshop (New York). The concept of the project, similar to the Teaching Table, involves the usage of digital manipualtives to teach pre-schoolers early math fundamentals. The system consists of a simple RFID setup with RF tags (embedded into shapes denoting numbers) and an RF antenna (which was embedded into a basket). Activities are carefully planned around this setup for the kids to interact and, at the same time, learn about a particular subject. An example of the activities is involving children to put numbers into the basket in correct order (1-10), and the system giving immediate feedback (by counting out loud the number and congratulating the child at successful attempts).

The form factor of 'Teaching Table' is very similar to that of digital artifacts described above (and in the "Related Works" section), but the interactions and activities supported represent a major shift in content paradigm. The emphasis is now on supporting standard curriculum practices and creating interactive activities to that end. For the purpose of the building a research prototype, the focus has been primarily on incorporating activities that teach mathematics skills. The activities would eventually be scalable and customizable, so that when fully functioning, they could support the full standard curriculum content for most subjects.

OBSERVING PRESENT PRE-K LEARNING PRACTICES

For the project to be successful, it is important to keep in mind the expectations and limitations of our target population – the children aged between 3 to 5 years – and their present learning environment. Hence, regular visits to school and observation of the learning patterns of the young students was included as an important part of the project methodology, both in the design and the development phase.

The observations during these school visits often helped in uncovering useful insights for the design of the table. For example, the author learned about the different skill levels and grasping ability that different pre-K students have in the same class. Presently, it is the responsibility of the teacher to keep everyone on the same page, which generally implies repetition until the last student has understood the concept being taught. This slows down the whole learning process, especially for the brighter students, who have already understood the concept in the first place. With a device like the Teaching Table, students can get individualized attention under the supervision of the teacher. More importantly, the students can learn at a pace convenient to them, and repetition for slow learners is not a problem for the whole class.

As mentioned before, in order to facilitate adoption of the device in the present day classrooms, the curriculum used by most pre-K schools (that specified by the State's education department) was consulted to develop the interactive activities for the system. For the purpose of demonstrating this on our research prototype, mathematics was selected as the subject of focus, and five main learning categories in mathematics were developed (inspired by the Georgia State Guidelines for Pre-K curriculum [Appendix-I]). These categories for the activities were aimed at developing the skills of:

1. Understanding numbers,
2. Creating and duplicating simple patterns,
3. Sorting and classifying objects,
4. Developing sense of space & understanding of basic geometric shapes, and
5. Learning to use a variety of non-standard and standard means of measurement.

These carefully designed activities will not only employ the interactive capabilities for maximum engagement, but do so in a way that is meaningful to the child in fostering better understanding. The activities presented here are only as sample for the research prototype, and the final set of activities are planned to cover a broader spectrum of pre-K curriculum subjects.

TAKING THE PROTOTYPE TO REAL-WORLD CLASSROOMS

After incorporating the knowledge gained from researching existing projects and observing the pre-K classrooms into a fully-functional interactive prototype, the final step in the research project involves exposing the prototype to the present classroom environment, and refining the project functionality and scope by learning in the process. In order to obtain maximum output from this step, it has been planned to be carried out in two phases:

1. Study with pre-K teachers, and
2. Study with pre-K children.

The two steps also represent emphasis on involving the two integral players in the classroom environment – the students and the teachers. In order to solicit important feedback, research study instruments have been designed that will guide the interaction with both these players. These instruments are a Focus Group study (involving teachers in a dialogue to obtain their expectations and requirements from a product like Teaching Table) and a Usability study (involving Pre-K students to identify usability and interaction issues with the table). These have been elaborated further in the section "User Studies" later in the document.

A research prototype has been developed to represent the physical form factor and the fundamental components of the Teaching Table in a working format. The prototype will also help demonstrate the functionalities and test the usability of the Teaching Table concept, and is currently capable of running selected full-length math curricular activities (mentioned later in this section).

The prototype integrates the major hardware and software components of the table (represented in the schematic diagram below) that are elaborated in the discussion that follows.

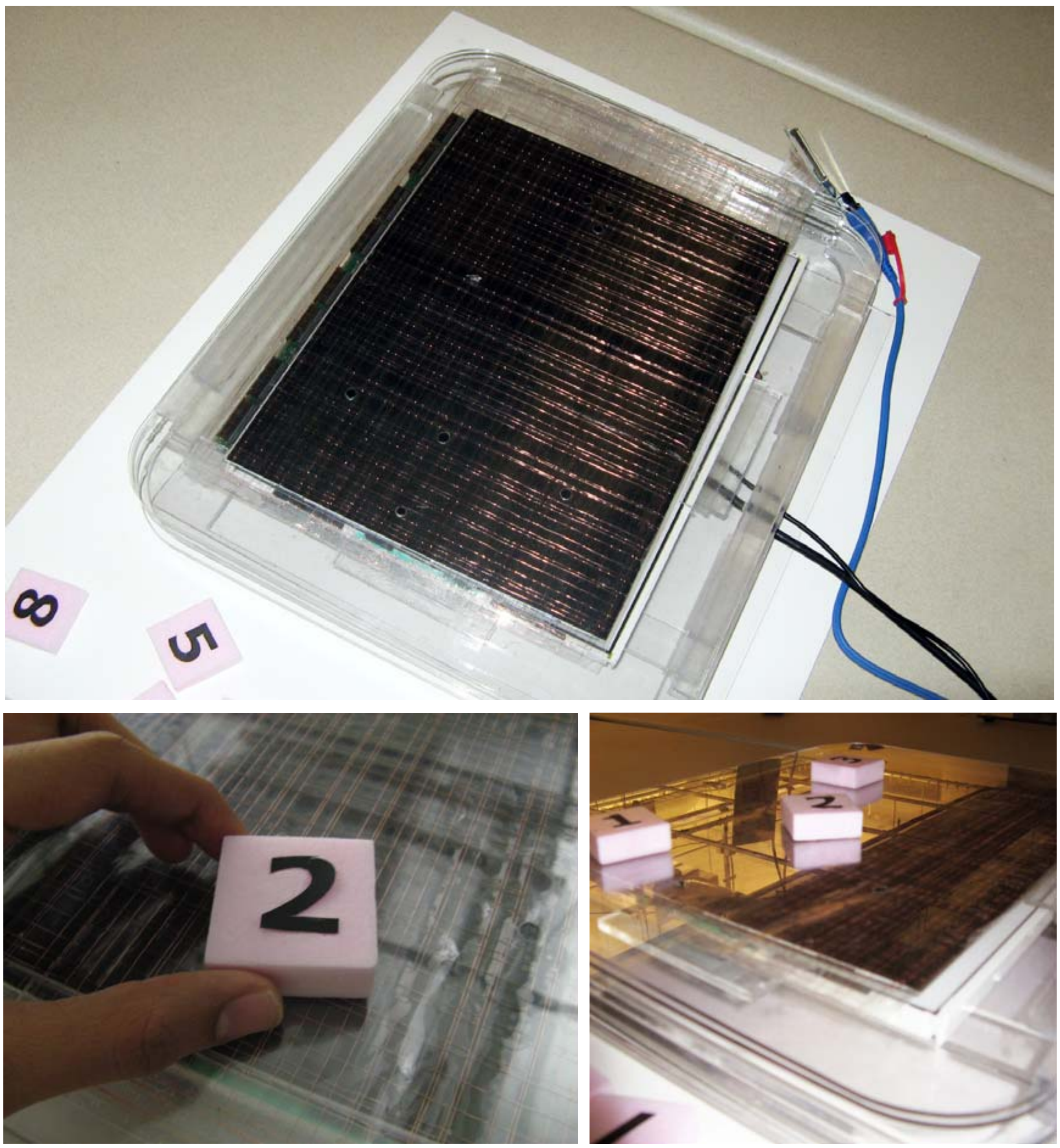


Figure 18: Photographs of the current Teaching Table prototype working

HARDWARE

The underlying technology in Teaching Table system hardware, based upon Ali Mazalek's (chair) prior research on tabletop sensing [41], is the Electromagnetic (EM) sensing technology which is used to enable accurate positioning of tagged physical objects as they are moved around on the table's surface. This technology is commercially available and was licensed, by a now dissolved company called Zowie Intertainment, for use in digitally enhanced toys [49]. The sensing is implemented by a sensing surface formed by a loosely wound grid of antenna wires, and a set of electromagnetically actuable tags that can be detected on the grid-surface. In the Teaching Table prototype, the tags have been attached to custom-built math manipulatives and blocks that are used during the educational activities. By sensing the presence and location of the tagged blocks on the wire grid, interaction is guided and activities are driven.

The sensing-grid setup lies on top of a horizontally placed LCD screen. The screen provides graphical output that coincides with the placement and movement of the objects on the sensing grid, enabling real-time visual feedback for a child's interactions with the physical pieces. Speakers are incorporated into the table setup to provide an additional audio feedback channel.

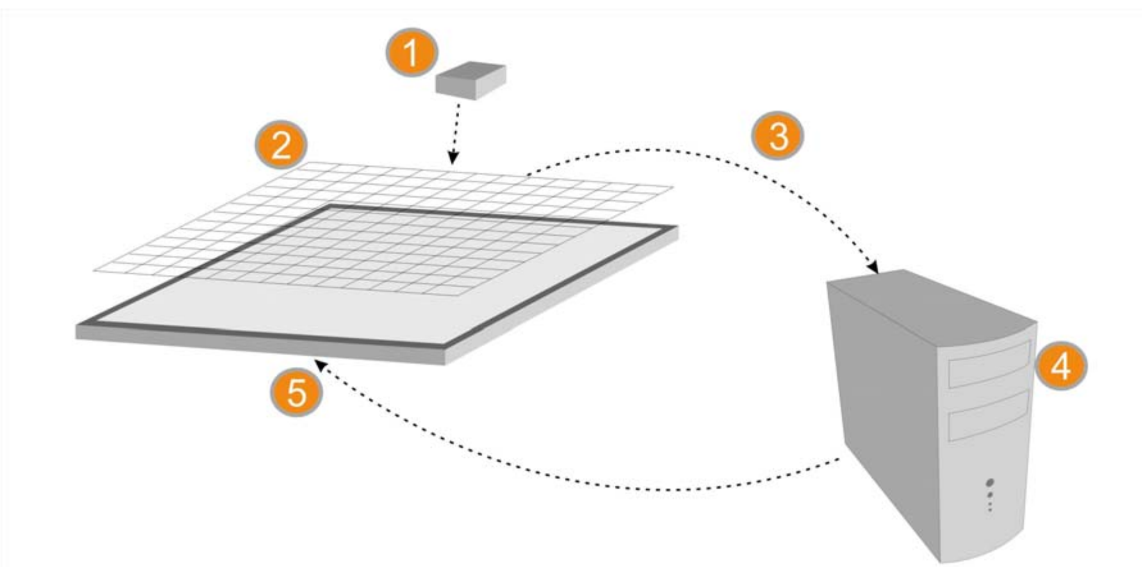


Figure 19: Hardware components of the Teaching Table and their working.

*When a tagged object **(1)** is placed on the EM sensing grid **(2)**, the ID and location of the object are sent **(3)** to the computer **(4)** which in turn controls the coincident display on the LCD screen **(5)**.*

The sensing system can communicate with the computer via the serial port through a firmware device. The LCD screen can also be connected to the same computer as an extended display, and the whole cycle of interaction – sensing, computing and responding – is completed in this way.

SOFTWARE

The Teaching Table software, implemented entirely in JAVA, consists of three main modules – one that handles the communication with the positioning hardware, other that controls the educational activities and the audiovisual output, and finally the one that enables administrative tasks and mentor assessment.

Object Sensing Module

The object sensing module enables communication between the sensing setup and the controlling computer. It is developed upon an event-based framework to interface with the hardware, which was originally developed by Prof. Ali Mazalek as a part of the generic API for interacting with the TViews table technology.

The module reads tag ID and position information via the serial port using a standard protocol and transmits it to the activity module, which updates its current state. In this way, the system is able to detect a child's physical actions on the table and can provide appropriate audiovisual feedback interactively. The playback of the different learning activities can be controlled from the primary screen of the computer console, which allows the teacher or mentor to present next activities and monitor a child's learning progress.

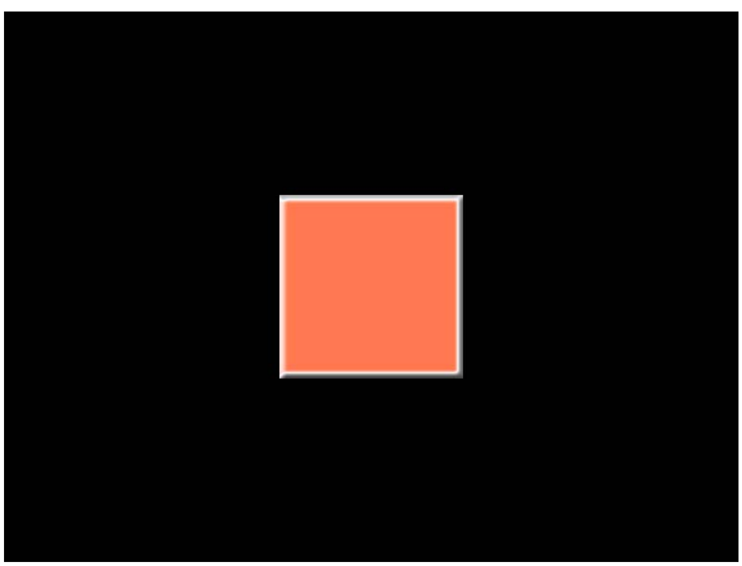


Figure 20: A screenshot of the LCD display showing a 'bin' where blocks would be placed.

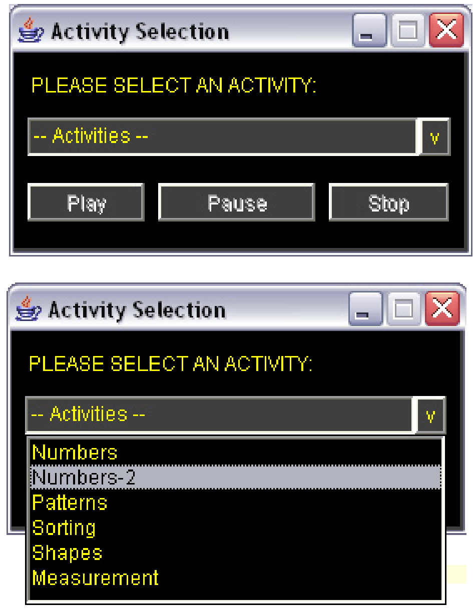


Figure 21: A screenshot of the activity control module to be controlled by the teachers

Activity Module

The main aim in designing the activities was to employ the interactive capabilities of the system in a way that can foster maximum understanding of concepts being taught while being informative and fun for the child. The activities attempt to involve the child by providing friendly voice-based feedbacks and cues coupled with visual feedback on the table's surface. The child is expected to respond by placing tagged objects (in the form of numbered blocks, geometric shapes, etc.) at appropriate places on the table.

In the continued effort to align the system with the needs of present-day schools, the activities were designed in accordance with the Georgia State Content Standards for Pre-K curriculum, which specifies the minimum level a child should attain after completing pre-K classes [26, Appendix I].

Following is a list of the categories and a brief description of activities currently supported by the system. For the complete script of all these activities, please refer to the section at the end of this document [Appendix II].

Categories of Activities

There are five main categories of activities that have been developed based on the Georgia State Pre-K Content Guidelines [26, Appendix I], as follows. Each category is illustrated by a sample activity:

Category 1: Activities to develop an understanding of numbers

Topics Covered: Counting by rote; identifying numbers etc.

Sample Activity: Putting the numbers 1-10 in order on the surface of the table.

Category 2: Creating and duplicating simple patterns

Topics Covered: Repeating patterns; completing incomplete patterns etc.

Sample Activity: Recreating a pattern (displayed on the screen) by placing blocks in the appropriate places.

Category 3: Sorting and classifying objects

Topics Covered: Identifying/sorting alike objects (all red together, all squares together) etc.

Sample Activity: Putting all the red blocks together, and all the blue blocks together.

Category 4: Activities to develop a sense of space and an understanding of basic geometric shapes

Topics Covered: Recognizing, describing and comparing basic geometric shapes etc.

Sample Activity: Similar to Category 1, only difference is that geometric shapes are used instead of numeral blocks.

Category 5: Learning to use a variety of non-standard and standard means of measurement

Topics Covered: Sorting, Ordering etc.

Sample Activity: Finding the block which is the largest among a given set of blocks.

Scaffolding

A noteworthy mention here is the functionality of 'scaffolding' included in the design of the activities. To facilitate the process of learning during the activities, this technique is used to reveal incremental amount of information to the child in case he/she makes mistakes at any step. For example, let's consider a scenario where a child is asked to identify the number 5 and to put it on the table but the child is not aware of the right answer. Using the scaffolding technique, the system gives increasingly informative hints to the child every time he/she makes a mistake, as is evident from the dialogue below:

Try 1: (The child puts the wrong block)
<System Voice> ***"Uh Oh! This is not the number 5. Try Again!"***

Try 2: (The child puts 8 instead of 5)
<System Voice> ***"This is not the number 5. This is the number 8. Please find the number 5 and put it in the bin"***

Try 3: (The child again fails to put the correct block)
<System Voice> ***"This is not the number 5. The number 5 looks like this…"***
<Table Display> 5
<System Voice> ***"Now find the number 5 and put it in the bin"***

Figure 12: An example of the scaffolding structure

Assessment Tools

An important feature of the Teaching Table from adoption point of view is the inclusion of software-based assessment tools to track the progress of a child interacting with the Teaching Table. This tool, based upon certain parameters, captures the activity and progress of each child interacting with the table, and displays the information to the teacher. This information would be of help to the teacher in the assessment of a child's progress, and also in deciding the kind of activities to be presented to the child.

The main parameters that the tool is planned to record are:

1. Success/Failure – If the child was able to complete a given activity in a pre-determined period of time. (Note that a child would be able to continue playing nonetheless.)
2. Time taken – The amount of time the child took to complete the activity (regardless of success or failure).
3. Number of unsuccessful attempts – The number of times the child had to be given hints for the completion of an activity.
4. Average time taken – The average of total times taken by all the students to complete an activity. This also helps the teacher in setting an appropriate completion time limit.
5. Adaptive activity selection – The system can keep track of the kinds of activity a child in which the child performs substandard. This information could help both the teacher and the system in determining which activities could be presented next. This would help in developing an overall learning progression or structure (i.e. sequence of activities towards a goal) for each child.

It is to be noted that the assessment tool is still under development, and the reviews obtained from the Focus Group study are planned to be incorporated into the tool before finalizing the features.

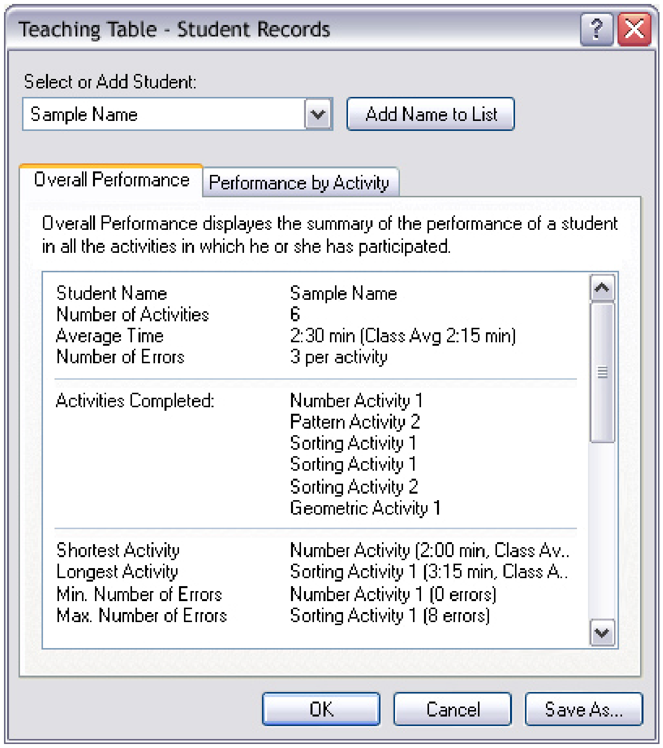


Figure 23: A mock-up screen of the assessment tool that would be used by the teachers.

An important step of the project is planned to ascertain whether the design of the Teaching Table meets the requirements and expectations of the stakeholders involved and if the product is usable in the classroom environment. To this end, a two-phased user inclusion strategy was planned that included **visiting pre-K classrooms** on a regular basis and **conducting standard user studies**.

For the final user study, two types of standard studies have been planned:

1. **Focus groups** involving teachers covering two issues:
    a. Features teachers are seeking in this artifact – expectations/needs etc., and
    b. Assessment methods that teachers want included in the table software
2. **Usability Study** involving children:
    a. Evaluating the usability of the physical artifact, and
    b. Identification of shortcomings in the interaction design.

It is to be noted here that although both the Focus group and Usability studies have been fully designed and planned, they remain to be conducted as currently they lie outside the scope of the project due to time constraints.

PRE-K SCHOOL VISITS

The school visits were conducted to the Centennial Place Elementary School to observe the day-to-day classroom environment. During the visits, the author served as a volunteer in a pre-K class at the school, gaining a first-hand experience of the class environment and making observations in the significant to the project deign. As stated earlier, the observations helped in two aspects of the table development - uncovering useful insights for the design of features for the table and in planning the final stage of standard user studies for the project.

Firstly, the school visits helped in better understanding the pre-K classroom environment. This included observing the present learning activities and how they are conducted by the teachers in the classroom. Since the Teaching Table would be primarily assisting the teachers in this task, the observations helped in deciding the right features for the table that would create easy division of work between the teachers and the table. Also observed were various other classroom functions of a teacher like distribution of resources, handling different skill-levels of the students and other management and administrative activities.

Secondly, these initial classroom visits also laid the foundation for a better design of the other two standard user studies – the Focus Group and the Usability Study, as described below.

FOCUS GROUP STUDY

In order to inform the design process of the Teaching Table and ensure the product developed is useful in the present classroom environment, it is planned to include pre-K teachers in the design process as focus group participants.

Focus groups provide the opportunity for people from similar fields to gather and discuss common issues which could be of immense help to researchers and designers in the field. Seeking similar effects, this focus group study is being organized to learn more about the features that pre-K teachers expect from early-education computational devices (like Teaching Table) in order to effectively augment their classroom math teaching. An additional goal is learning about the various assessment methods the teachers use to evaluate the progress of their students, as this would inform the design of assessment tools included in the Teaching Table.

To summarize, the main objectives for conducting this study are:

1. To determine the feasibility of using a Teaching Table like system in a classroom setting
2. To determine the preferred ways of assessment of a child's progress – parameters that should be recorded by the Teaching Table system that could be later be of help to a teacher evaluating pre-K students.

Analytic Questions motivating the focus group study

Analytic questions are high-level issues that a study seeks to research further during its course. For our present case, the most important questions are as follows:

1. How do the teachers view technology in classrooms? Are there examples where teachers think technology enhanced their teaching?
2. Would teachers be interested in having a computationally-enhanced device that may augment their teaching and assessment of students? What features would teachers be expecting in such a device?

3. How would teachers envision using this device to not only augment their teaching but also assess the progress of their students?
4. What are the current methods and tools used by pre-K teachers for assessing the math performance of individual students?
5. What kinds of performance indicators do pre-K teachers seek during assessment? Are these same as the guidelines set up by the State?
6. After being informed about a particular type of device, tentatively called 'The Teaching Table,' what are their reactions, comments and criticisms about the device? What suggestions do they have that they believe can enhance the learning, teaching, and assessment experience? (For example, do they want more/less control of the activities being explored?)
7. When using the proposed Teaching Table, what data would they need from it to assess a child's performance? In what formats would they like feedback on students?

Detailed Methods

Before the commencement of the study, the pre-K teachers from the Centennial Place Elementary School will be contacted and recruited for the focus group study as detailed below. Eight of the teachers who consent to participate in the study will be invited to a group discussion session which will be scheduled according to the preferences of the participants.

There will be two researchers conducting the study – a moderator and a note-taker. Before the discussion starts, the eight participants will be briefed and provided an account of the purpose of the study, and asked to sign a consent form. Then the moderator will invite the participants for a semi-structured group discussion, with the overall direction of the discussion being guided by the issues listed in the 'Analytic Questions' section above.

During the discussion, the concept of Teaching Table will be presented to the participants, and they will be encouraged to comment on various features of the device. The whole discussion will be videotaped for the purposes of transcription and reporting. Finally, it is planned to erase the videotapes once the transcription is complete and the group discussion information has been shared within the team of researchers.

As a part of the compensation a $10 Barnes and Noble gift card or a similar reward would be provided to each of the participants. They will be allowed to leave the study at any time without any negative consequences, however, their reward may be held based on the discretion of the researchers in such a case.

Recruitment/Sampling

There will be 8 pre-K teachers selected as participants for the study. This number is optimal for bringing people with diverse backgrounds without making the group too big and formal (Krueger, 1994). A screener will be used to select a pool of 12-15 teachers who have had at least 2 years of teaching and assessment experience before participating in the study. The participants will be selected from a group of pre-K teachers. For the purposes of consistency, teachers who follow similar curriculum standards (e.g. Georgia Early Education Content Standards) and teach in the schools that cater to the same socio-economic strata will be selected for the study.

USABILITY STUDY

The usability study is planned to be an important part of the user study phase, as it tests the design with the primary user group of the Teaching Table. The main objectives of the usability study are:

1. To evaluate whether the system is physically usable by kids (ages 3-5 years) in a typical classroom setting.
2. To evaluate whether the interaction activities are appropriate for the age group, and are understood by the children.

This study would be an on-site evaluation, observing children play with the teaching table in their regular classroom environment. Given the target users of 3-5 yr old children from a pre-K class, the methods of cognitive walkthrough, think-aloud protocol and contextual inquiry etc. are unsuitable for study purposes. Field observation method, including question asking and performance measurement would be the more suitable in this case.

Evaluation Focus

The study plans to understand more about the usability of the Teaching Table, specifically focusing on the following parameters/aspects:

Parameter/Aspect	Method of evaluation
Size of the blocks	Between designs – vary size of blocks
Voice Quality	Between designs (control design and normal) – vary audio output (gender, age, affect)
Visibility of the screen	Between designs/Question asking

Feedback	Vary amount of feedback
Learnability	Between products/method. Observe performance using Teaching Table v/s other methods.
Error prevention within the system	Number of errors made by the children. Number and types of system breakdown.
Performance	Time duration of each step and the overall activities
Presentation of the problem to the children (wordings of the activity dialogue)	Standard repetition.
Interruptability/Attention holding	Subjective observation
Information Architecture / Flow of the activities	Subjective observation
Learning effects	Full-scale study planned for future.

Detailed Methods

The usability study is planned to include 12-15 pre-K students, preferably within the age range of 3-5 years for consistency throughout the study. Screeners will be used to determine other parameters, like slow learners/fast learners, introverts/extroverts, for participation. Upon obtaining consent from the parent/guardians of the participating children (after a pilot test), they will be asked to complete activities on the Teaching Table. The children will be grouped in to regular and control subjects to rule out any confounding parameters that might effect the outcome of the study.

Each child will be asked to solve a math problem before and after completing a related activity on the Teaching Table. During the process of performing an activity, the investigators will make a note of the various issues/breakdowns they perceive with the system. At the same time, questions will be asked brief questions to obtain their immediate response to the system. The whole process will be videotaped for sharing amongst the researchers, and the recordings will be destroyed thereafter.

The observation made during these tasks, along with the performance of the children in these activities will be used to make decisions about modifications of the design.

conclusion and future work

This document has presented the concept and design of a tangible and interactive educational device called the Teaching Table. The table is built upon a scalable and robust framework that lends flexibility to the type of activities that could be performed on it. The power of the Teaching Table platform also lies in its generic nature and that the activities, fostering development of a variety of skills for the kids, can be constructed and supported easily by using such a platform. The interaction with the table, owing to its tangible nature, is very simple and intuitive, and special attention has been given to making the product easily adoptable in the present classroom environment. The robustness of the system in detecting objects and sensing location – all through wireless EM technology, makes this platform a prime candidate for the present tangible computing application. Additionally, the output-display can be visually linked to the physical artifacts being manipulated – giving a true impression of a tangible interface.

To continue the development efforts for the Teaching Table, a number of steps have been planned to be completed in future. The most important among these are extension of the prototype software to include more activities and conducting the planned usability study for the table. There are also plans to develop collaborative activities to enable small groups of children interacting on and with the table together.

The first important proposed addition to the Teaching Table is the extension of activities to include a broader spectrum of pre-K curricula. While the current research prototype focuses on the development of only math skills, it would not be difficult to extend the activities to cover concepts in other areas, such as language and literacy, science, and creative development.

The other proposed step is the evaluation of the Teaching Table setup by taking it to real classroom environments and observing children and teachers interact with it, as described in the section 'user studies' above. In particular, detailed learning studies need to be carried out that can determine the system's positive (or negative) effects on student learning, and that compare it to use of traditional artifacts and to the absence of use of any artifact. This should help us gain insights into potential improvements in hardware and activities for the future.

Also, our initial assumption of being able to build a stand-alone device has still not been realized due to prototyping resource constraints, and would be an interesting modification to be made in the future.

On a final summary note, although a thorough design foundation has been laid for the Teaching Table system to be truly helpful in a classroom environment, the implementation and testing phases still need to be completed, and there might be changes/modifications in the times ahead. In the meanwhile, hopefully the extensive design and documentation of the system would help in extending the project into future and add value to the present education system.

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Extract from Georgia's *Bright from Start* – math content standards for pre-K education

1. Children will begin to develop an understanding of numbers:

	Performance Indicators	Learning in Action	K GPS
MD 1 a	Counts by rote	• Counts in finger plays or rhymes • Sings a counting song	MKN1a, SKCS2a
MD 1 b	Arranges sets of objects in one-to-one correspondence	• Matches blocks with animals • Places a spoon on each plate at the table	MKN1a
MD 1 c	Counts objects using one-to-one correspondence	• Counts manipulatives • Counts the number of children present	MKN1a
MD 1 d	Compares sets of objects using language	• Identifies "more than, less than or same" when comparing two groups • Explains that all of the long sticks are in one box and all the short sticks are in another box	MKN1e, MKN2a, MKN2b, MKN2c
MD 1 e	Begins to understand concept of part and whole using real objects	• Recognizes the difference between a whole apple and part of an apple	MKN1g
MD 1 f	Begins to identify ordinal numbers	• Lines objects on table and points to first in line and the last in line • Standing in line and says, "I am first, and you are second"	MKN1d
MD 1 g	Associates numeral name with set of objects	• Counts four objects and says, "I have four bears."	MKN1c
MD 1 h	Begins to understand the concept of currency as a means of exchange	• Sorts coins during a small group activity • Uses play money to purchase items from a pretend classroom store	SSKE3b, MKN1h, MKN1i, MKN1j
MD 1 i	Begins to understand the concept of estimation	• Estimates the number of marbles in a jar • Estimates how many steps it will take to get to the playground • Estimates how many cups of water it will take to fill a pitcher	MKN1f, SKCS2b
MD 1 j	Begins to recognize numbers	• Says, "I see the number 2," while pointing to the morning message board • Matches the correct number of counters to the number card and says, "Here is the number 4."	MKN1c

2. Children will create and duplicate simple patterns:

	Performance Indicators	Learning in Action	K GPS
MD 2 a	Copies a pattern using sounds or physical movements	• Snaps, claps, stomps a rhythmic pattern	
MD 2 b	Recognizes and reproduces simple patterns of objects	• Creates patterns using manipulatives, blocks or other objects in the classroom	MKG3a
MD 2 c	Reproduces and extends a pattern using objects	• Sees the pattern in a string of beads and determines which bead is needed	MKG3a

		to continue the pattern	
MD 2 d	Independently creates patterns using objects	• Creates patterns using manipulatives, blocks, or other objects in the classroom	MKG3b
MD 2 e	Spontaneously recognizes and identifies patterns in the environment	• Recognizes patterns in rugs, clothes, daily schedule • Recognizes repeated phrases in stories	

3. Children will sort and classify objects:

	Performance Indicators	Learning in Action	K GPS
MD 3 a	Matches like objects	• Places all of the dinosaurs together	SKP1a, SKP1b
MD 3 b	Sorts objects using one characteristic	• Places all of the red blocks together and all of the green blocks together • Places the big animals in one group and small animals in another group • Sorts all of the pennies, nickels, and dimes into the appropriate groups.	SKP1a, SKP1b, SKP2a
MD 3 c	Classifies objects using more than one characteristic	• Makes a grouping of red triangles, green triangles, red squares, and green squares (sorted by color and shape)	SKP1a, SKP1b, SKL1b, SKL1c
MD 3 d	Sorts and classifies objects using self-selected criteria	• Sorts through a box of buttons and makes up rules for organization	SKP1a, SKP1b, SKL1b, SKL1c
MD 3 e	Explains sorting or classifying strategy	• Sorts items and says, “I put all of the big animals together.”	SKL2a, SKL2b, SKL2d
MD 3 f	Participates in creating and using real and pictorial graphs or other simple representations of data	• Helps to create a graph of types of shoes worn in the classroom by placing shoes on a floor graph • Helps to creates a chart of favorite foods by placing name or symbol under the correct column	MKD1

4. Children will develop a sense of space and an understanding of basic geometric shapes

	Performance Indicators	Learning in Action	K GPS
MD 4 a	Recognizes, describes and compares basic geometric shapes	• During group time says, “I am sitting on a square.” • Notes that the classroom door is a rectangle • Using unit blocks, notices that a square has four sides and a triangle has three sides	MKG1a, MKG1e, SKCS5a
MD 4 b	Uses classroom materials to create shapes	• Combines unit blocks to make shapes • Forms shapes using play dough	MKG1c, MKG1d, MKG1e
MD 4 c	Uses language to indicate where things are in space: positions, directions, distances, order	• Uses positional words such as over, under, behind during play • Places an object inside and outside, behind and in front, under and above, beside and on a box on a table	MKG2a, MKG2b

5. Children will learn how to use a variety of non-standard and standard means of measurement

	Performance Indicators	Learning in Action	K GPS
MD 5 a	Associates and describes the passage of time with actual events	• Notes that snack time is after outdoor time • Remarks that yesterday was special because of the trip to the library • Recalls daily schedule • Uses words to describe time intervals such as, yesterday, today, and tomorrow	MKM2a, MKM2b, MKM3a, MKM3b, MKM3c, SSKH3a, SSKH3b, SSKH3c, SSKH3d, SSKH3e, SSKH3f, SSKH3g, SKE1a
MD 5 b	Uses mathematical language to describe experiences involving measurement	• Uses comparison terms, such as, "My block is longer than yours" (heavy/light, big/little, tall/short)	MKM1a, MKM1b, MKM1c, MKM1d
MD 5 c	Measures the passage of time using non-standard or standard measures	• Uses the sand timer to measure time at the computer	SKE1a
MD 5 d	Measures the length of objects using non-standard or standard measures	• Uses links to measure the length of a table • Uses hands, feet, or string to measure length • Uses a ruler to measure the length of a block	MKM1a, MKM1b, MKM1c, MKM1d, SKCS3a
MD 5 e	Measures the volume (capacity) of objects using non-standard or standard measures	• Uses a cup or plastic container to measure the water in the sensory table Uses measuring cups to measure ingredients for a recipe	MKM1a, MKM1b, MKM1c, MKM1d
MD 5 f	Measures and compares the weight of objects using non-standard or standard measures	• Holds a block in each hand and identifies which is heaviest Uses balance scale to compare weight of small blocks and plastic cubes	MKM1a, MKM1b, MKM1c, MKM1d, SKCS4b, SKCS4c, SKCS6b
MD 5 g	Orders two or more objects by size (seriation)	• Uses blocks of three different sizes and places in order of size-small, medium, large Arranges four rods from shortest to longest	SKCS4c

[1] Number Activity 1: Identifying numbers

NUM: "1", "2", "3", "4", "5", "6", "7", "8", "9" (*statement, question, exclamation*)

ID #	Audio	Logic
11_01 ID_ BEGIN		System generates a random number between 1-10
11_02	Please find the number <NUM> and place it inside the bin	
11_03		Display: Bin
11_04 ID_WAIT		System waits for a response. If a response is detected before timeout limit, go to ID_RESPOND, otherwise go to ID_TIMEOUT
11_05 ID_RESPOND		System checks if the number detected is correct or not. If correct, go to ID_CORRECT (or ID_CORRECT_ALT) otherwise go to ID_WRONG
11_06 ID_WRONG[1]	Uh Oh! This is not the number <NUM>. Try Again!	Attempt 1: The number detected is wrong. Go to ID_WAIT
11_07 ID_WRONG[2]	This is not the number <NUM>. This is the number <NUM>. Please find the number <NUM> and put it in the bin	Attempt 2: The number detected is wrong. Go to ID_WAIT
11_08 ID_WRONG[3]	This is not the number <NUM>. The number <NUM> looks like this… Now find the number <NUM> and put it in the bin	Attempt 3: The number detected is wrong. Display: <NUM> on Bin Go to ID_WAIT
11_09 ID_TIMEOUT	Did you find the number <NUM>? Please find the number <NUM> and put it in the bin!	Timeout response. Go to ID_WAIT
11_10 ID_CORRECT	Yay! You found the number <NUM>!	Go to ID_ BEGIN
11_11 ID_CORRECT_ALT	Good Job! You put the number <NUM> in the bin!	Go to ID_BEGIN

[1] Number Activity 2: Counting from 1-10

ID #	Audio	Logic
12_01 ID_ BEGIN	Please find the number one and place it inside the bin	Display: Bin at top-left corner Go to ID_WAIT
12_02 ID_ NEXT	Now, find number <NEXT-NUM> and place it inside the new bin	Display: next Bin
12_03 ID_WAIT		System waits for a response. If a response is detected before timeout limit, go to ID_RESPOND, otherwise go to ID_TIMEOUT
12_04 ID_RESPOND		System checks if the number detected is correct or not. If correct, go to ID_CORRECT (or ID_CORRECT_ALT) otherwise go to ID_WRONG
12_05 ID_WRONG[1]	Uh Oh! This is not the number <NUM>. Try Again!	Attempt 1: The number detected is wrong. Go to ID_WAIT
12_06 ID_WRONG[2]	This is not the number <NUM>. This is the number <NUM>. Please find the number <NUM> and put it in the bin	Attempt 2: The number detected is wrong. Go to ID_WAIT
12_07 ID_WRONG[3]	This is not the number <NUM>. The number <NUM> looks like this… Now find the number <NUM> and put it in the bin	Attempt 3: The number detected is wrong. Display: <NUM> on Bin Go to ID_WAIT
12_08 ID_TIMEOUT	Did you find the number <NUM>? Please find the number <NUM> and put it in the empty bin!	Timeout response. Go to ID_WAIT
12_09 ID_CORRECT	Yay! You found the number <NUM>!	Go to ID_ NEXT
12_10 ID_CORRECT_ALT	Good Job! You put the number <NUM> in the bin!	Go to ID_ NEXT

[2] Pattern Activity 1: Completing a pattern

PROPERTY: “COLOR”, “SHAPE”
RESPONSE: “RED BLOCK”, “BLUE BLOCK”, “GREEN BLOCK”, “SQUARE”, “CIRCLE”, “TRIANGLE”

ID #	Audio	Logic / Comments
21_01 ID_ BEGIN	Let’s play a new game! Look at the pattern on the screen. Look carefully, because there is one piece missing.	Display: Pattern-1
21_02	Can you find the missing <PROPERTY> block and put it in the right place?	
21_03 ID_WAIT		Wait for a response. If a response is detected before timeout limit, go to ID_RESPOND, otherwise go to ID_TIMEOUT
21_04 ID_RESPOND		Check if the number detected is correct or not. If correct, go to ID_CORRECT (or ID_CORRECT_ALT) otherwise go to ID_WRONG
21_05 ID_WRONG[1]	Uh Oh! This is not the right <PROPERTY> Try Again!	Attempt 1: The number detected is wrong. Go to ID_WAIT
21_06 ID_WRONG[2]	You put a <RESPONSE>, but there is no <RESPONSE> missing. Try Again!	Attempt 2: The number detected is wrong. Go to ID_WAIT
21_07 ID_WRONG[3]	Look at the top and bottom line of blocks on the screen to find the missing block.	Attempt 3: The number detected is wrong. Go to ID_WAIT
21_08 ID_WRONG[4]	Hmmm… Let’s think about this. Do you see a <RESPONSE> missing on the table? Put a <RESPONSE> in the right place to see if it works!	Attempt 4: The number detected is wrong. Display: Blink <RESPONSE> in the Bin Go to ID_WAIT
21_09 ID_TIMEOUT	Please find the right <PROPERTY> and put it in the empty bin!	Timeout response. Go to ID_WAIT
21_10 ID_TIMEOUT_ALT	I’m waiting! Find the right <PROPERTY> and put it in the empty bin!	
21_11 ID_CORRECT	Yay! You found a <RESPONSE>. That is the right <PROPERTY>. Good Job!	Go to ID_ NEXT

[2] Pattern Activity 2: Copying a pattern

RESPONSE: “SQUARE”, “CIRCLE”, “TRIANGLE”
POSITION: “FIRST”, “SECOND”, “THIRD”

ID #	Audio	Logic / Comments
22_01 ID_BEGIN	Let’s play another game! Look at the blocks on the screen.	Display: Pattern-1
22_02	Now, can you put your squares, triangles and circles in the bins, so that they look like the blocks already on the screen? Go on…	
22_03 ID_NEXT	Go ahead, now find the right block for the next bin.	
22_04 ID_WAIT		Wait for a response. If a response is detected before timeout limit, go to ID_RESPOND, otherwise go to ID_TIMEOUT
22_05 ID_RESPOND		Check if the number detected is correct or not. If correct, go to ID_CORRECT (or ID_CORRECT_ALT) otherwise go to ID_WRONG
22_06 ID_WRONG[1]	Uh Oh! That is not what the <POSITION> block looks like. Look closely and try again!	Attempt 1: Incorrect block detected. Go to ID_WAIT
22_07 ID_WRONG[2]	You put a <RESPONSE>, but the <POSITION> block is not a <RESPONSE>. Try Again!	Attempt 2: Incorrect block detected again. Go to ID_WAIT
22_08 ID_WRONG[3]	The <POSITION> block is a <RESPONSE>. Can you find a <RESPONSE>, and put it in the <POSITION> bin?	Attempt 3: The number detected is wrong. Go to ID_WAIT
22_09 ID_TIMEOUT	Please find the right shape and put it in the next bin.	Timeout response. Go to ID_WAIT
22_10 ID_TIMEOUT_ALT	I’m waiting! Did you find the right shape for the <POSITION> bin yet?	
22_11 ID_CORRECT	Yay! You found a <RESPONSE>. That’s the right shape. Good Job!	Go to ID_NEXT

[3] Sorting Activity 1: All identical shapes/colors together

PROPERTY: “COLOR”, “#SHAPE”
COLOR: “RED”, “BLUE”, “GREEN”
RESPONSE: “RED BLOCK”, “BLUE BLOCK”, “GREEN BLOCK”, “#SQUARE”, “#CIRCLE”, “#TRIANGLE”
RESPONSE MULTIPLE: “RED BLOCKS”, “BLUE BLOCKS”, “GREEN BLOCKS”, “#SQUARES”, “#CIRCLES”, “#TRIANGLES”

= The activity will not be included in the prototype version

ID #	Audio	Logic / Comments
31_01 ID_BEGIN	Okay, ready for the next game?	Display: Pattern-1
31_02	You’ve got blocks of many colors. Can you find all the <RESPONSE MULTIPLE>, and put it in the bin?	
31_03 ID_WAIT		Wait for a response. If a response is detected before timeout limit, go to ID_RESPOND, otherwise go to ID_TIMEOUT
31_04 ID_RESPOND		Check if the number detected is correct or not. If correct, go to ID_CORRECT (or ID_CORRECT_ALT) otherwise go to ID_WRONG
31_05 ID_WRONG[1]	Hmmm… This is not what the <PROPERTY> <COLOR> looks like. Think and try again!	Attempt 1: Incorrect block detected. Go to ID_WAIT
31_06 ID_WRONG[2]	Oh Uh! You’ve put a <RESPONSE>, but we need only <RESPONSE MULTIPLE>. Can you find only the <RESPONSE MULTIPLE> and put it in the bin?	Attempt 2: Incorrect block detected again. Go to ID_WAIT
31_07 ID_WRONG[3]	This block is a <RESPONSE>, but a <RESPONSE> looks like this... Can you now find all the blocks that are <COLOR>?	Attempt 3: The number detected is wrong. Go to ID_WAIT
31_08 ID_TIMEOUT	Go ahead, find all the <RESPONSE> and put it in the bin!	Timeout response. Go to ID_WAIT
31_09 ID_TIMEOUT_ALT	I’m still waiting!	
31_10 ID_CORRECT	Yay! You found all the <RESPONSE MULTIPLE>. Great Job!	Go to ID_NEXT

[4] Geometric Activity 1: Identifying basic geometric shapes

PROPERTY: "#LINE, SQUARE, CIRCLE, RECTANGLE, TRIANGLE"

= The activity will not be included in the prototype version

ID #	Audio	Logic / Comments
41_01 ID_BEGIN	Here's the next game!	
41_02	Let's see if you know shapes and their names. I will ask you for a shape and you will have to put it in the bin. Ready? Here we go…	
41_03 ID_NEXT	Can you find any <PROPERTY> in the blocks and put it in the bin?	
41_04 ID_WAIT		Wait for a response. If a response is detected before timeout limit, go to ID_RESPOND, otherwise go to ID_TIMEOUT
41_05 ID_RESPOND		Check if the number detected is correct or not. If correct, go to ID_CORRECT (or ID_CORRECT_ALT) otherwise go to ID_WRONG
41_06 ID_WRONG[1]	Hmmm… This is not what a <PROPERTY> looks like. Think and try again!	Attempt 1: Incorrect block detected. Go to ID_WAIT
41_07 ID_WRONG[2]	Oh Uh! You've put a <PROPERTY>, but we need a <PROPERTY>. Look again and find the <PROPERTY> and put it in the bin.	Attempt 2: Incorrect block detected again. Go to ID_WAIT
41_08 ID_WRONG[3]	This block is a <PROPERTY>, but we're looking for a <PROPERTY> which looks like this... Can you now find a block that is a <PROPERTY>?	Attempt 3: The number detected is wrong. Display correct shape. Go to ID_WAIT
41_09 ID_TIMEOUT	Go ahead. Find a <PROPERTY> and put it in the bin!	Timeout response. Go to ID_WAIT
41_10 ID_TIMEOUT_ALT	I'm still waiting!	
41_11 ID_CORRECT	Yay! You found a <PROPERTY>. Great Job!	Go to ID_NEXT
41_12 ID_CORRECT	Hooray! You know the right answer!	Go to ID_NEXT

[5] Measurement Activity 1: Telling time – Mini exercise

HOUR: "ONE, TWO, THREE, FOUR, FIVE, SIX, SEVEN, EIGHT, NINE, TEN, ELEVEN, TWELVE"
MINUTE: "FIVE, TEN, FIFTEEN, TWENTY, TWENTY-FIVE, THIRTY, THIRTY-FIVE, FOURTY, FOURTY-FIVE, FIFTY, FIFTY-FIVE"

ID #	Audio	Logic / Comments
51_01 ID_BEGIN	Let's play Tell-Times!	
51_02	Use the hands of the clock to show a time, and I'll tell you what time it is. Go ahead and put the clock in the bin first.	
51_03	Now, move the hands of the clock, and stop whenever you want!	
51_04 ID_WAIT		Wait for a response. If a response is detected before timeout limit, go to ID_RESPONSE, otherwise go to ID_TIMEOUT
51_05		Check if the hands have stopped moving. Go to ID_RESPONSE
51_06 ID_RESPONSE	Okay, The time in the clock is almost <HOUR> hour and <MINUTE> minutes.	If the hour is "ONE"
51_07 ID_RESPONSE _PLURAL	Okay, The time in the clock is almost <HOUR> hours and <MINUTE> minutes.	If the hour is not "ONE"
51_08 ID_RESPONSE_ALT	Hmmm… the time is almost <HOUR> <MINUTE>. Can you remember that?	
51_08 ID_TIMEOUT[1]	Go ahead. Move the hands! To begin, just see how the hands in your classroom clock are, and try to copy it… (?)	Timeout response for the first time. Go to ID_WAIT
51_10 ID_TIMEOUT[2]	This is fun! Move the hands again to see the new time.	Timeout response. Go to ID_WAIT
51_11 ID_CORRECT	Great Job! You found how to show <HOUR> o'clock!	Go to ID_NEXT
51_11 ID_CORRECT	Wow! That is right! You are very good at this.	Go to ID_NEXT

[5] Measurement Activity 2: Identifying time

HOUR: "ONE, TWO, THREE, FOUR, FIVE, SIX, SEVEN, EIGHT, NINE, TEN, ELEVEN, TWELVE"
MINUTE: "FIVE, TEN, FIFTEEN, TWENTY, TWENTY-FIVE, THIRTY, THIRTY-FIVE, FOURTY, FOURTY-

ID #	Audio	Logic / Comments
52_01 ID_BEGIN	Do you know how to tell time? I will ask you to show a time, and you will have to move the hands of your clock to show that time. Are you ready?	
52_02	Okay, first show me twelve o'clock. Do you remember how the clock shows twelve o'clock?	
52_03 QUESTION	Now, can you show the time <HOUR><MINUTES> on your clock?	
52_04		Check if the hands have stopped moving. Go to ID_RESPONSE. If no response is detected, go to ID_TIMEOUT.
52_05 ID_RESPONSE		Check if the hands show the correct time. If yes, go to ID_CORRECT, otherwise go to ID_WRONG
52_06 ID_TIMEOUT[1]	Go ahead. Move the hands of your clock!	Timeout response for the first time. Go to ID_WAIT
52_07 ID_TIMEOUT[2]	I'm waiting for you… turn the hands of the clock!	Timeout response alt. Go to ID_WAIT
52_08 ID_WRONG	Uh oh! That's not how the clock shows <HOUR><MINUTES>. Try again.	
52_09 ID_WRONG[2]	Hmmm…. That's not <HOUR><MINUTE>, that is how the clock shows about <HOUR> <MINUTE>. Think and try again!	If the child gives the incorrect answer twice.
52_10 ID_WRONG[3]	The clock shows <HOUR><MINUTES> like this, can you make this with the clock-hands you have? Go ahead!	If the child gives the incorrect answer thrice.
52_11 ID_CORRECT	Great Job! You showed the time <HOUR><MINUTES> correctly on the clock.	

Sample activities for children: Using blocks of three different sizes and placing them in order of size-small, medium, large; arranging four rods from shortest to longest

[5] Measurement Activity 2: Compare objects by size

PROPERTY: "SMALLEST, BIGGEST"
ORDER: "FIRST, SECOND, THIRD, FOURTH"

ID #	Audio	Logic
53_01 ID_ BEGIN	Do you have the four rods given to you? Please arrange them on the bin from smallest to the longest.	Display: Bin at top-left corner Go to ID_WAIT
53_02	Go on, pick the rod that is the smallest, and put it in the blinking bin.	Display: first Bin
53_02 ID_ NEXT	Now, find the rod that is <ORDER?><PROPERTY> and put it in the flashing bin.	Display: next Bin
53_03 ID_WAIT		System waits for a response. If a response is detected before timeout limit, go to ID_RESPOND, otherwise go to ID_TIMEOUT
53_04 ID_RESPOND		System checks if the rod detected is correct or not. If correct, go to ID_CORRECT (or ID_CORRECT_ALT) otherwise go to ID_WRONG
53_05 ID_WRONG[1]	Uh Oh! That is not the <ORDER?><PROPERTY> rod. Try Again!	Attempt 1: The rod detected is wrong. Go to ID_WAIT
53_06 ID_WRONG[2]	That is not the <ORDER?><PROPERTY> rod. This is the <ORDER?><PROPERTY> rod. Please find the <ORDER?><PROPERTY> rod and put it in the bin	Attempt 2: The rod detected is wrong. Go to ID_WAIT
53_07 ID_WRONG[3]	This is not the <ORDER?><PROPERTY> rod. The <ORDER?><PROPERTY> rod looks like this… Now find the right rod and put it in the bin	Attempt 3: The rod detected is wrong. Display: correct rod on Bin Go to ID_WAIT
53_08 ID_TIMEOUT	Did you find the <ORDER><PROPERTY> rod yet? I'm waiting…	Timeout response. Go to ID_WAIT
53_09 ID_CORRECT	Yay! You found the <ORDER?><PROPERTY> rod!	Go to ID_ NEXT
53_10 ID_CORRECT_ALT	Good Job! You found the <ORDER?><PROPERTY> rod correctly!	Go to ID_ NEXT

Focus group moderator's guide

I. OPENING COMMENTS AND INTRODUCTIONS (10 MINUTES)

Objective

To put participants at ease by explaining the purpose and procedures for the group and by facilitating self-introductions to help participants become comfortable with each other and the moderator.

Moderator will:

-Introduce herself/himself and thank participants for attending.

-Identify topic in broad terms and explain the purpose of the discussion.

-Explain the presence and purpose of recording and note-taker.

-Encourage participants to speak candidly.

-Note that participants' names will not be used in any report and comments are kept confidential.

-Facilitate participants' introductions

Example of approach, to be modified to fit moderator's style:

Greetings

Good day everyone. My name is ____________________. Thank you for agreeing to participate in the discussion today. I have been asked to talk with you about the use of technology in pre-K classrooms and also introduce to you a new teaching device being developed at the Synlab at Georgia Tech. We are interested in your experiences, opinions, and ideas concerning the device, and technology in your classrooms in general, that you would like to share with us today.

Guidelines

Before we begin the discussion, I want to go over just a few guidelines that will help us cover all the questions I have:

Please bear in mind that this is a study to gather information; there are no right or wrong answers. I encourage you to be candid about your personal view on any of the topics that come up. I will not use anyone's name in the report and hope that will help you feel comfortable speaking your mind.

Our discussion will be recorded so that I can concentrate on talking with you. This recording will be destroyed as soon as we are through transcribing the discussion and no names will be associated with the transcription. Also with me is ________, who will be taking notes.

Please do not be offended if I must interrupt you to move on to another topic. I'd like to get at least a little bit on many different topics and that may make us feel a bit rushed. If I must cut you off, I will try to come back to you later on.

Introductions

Some of you know each other already, but I would like to go around the table to have everyone introduce him or herself to make sure I have all of your names.

II. TEACHING MATH IN GENERAL (15 MINUTES)

Objective

To gain a general understanding of the current methods and tools used by the participants in teaching math and assessing student's progress

How do you INTRODUCE and TEACH early math concepts to your pre-K students?

--Probe:

1. Are there any specific methods, if any, you use?
2. Are there any specific tools you use (playset/artifact/object)? How do you use them in the classroom setting?
3. Do you all follow the curriculum guidelines set by the Georgia State? If yes, how closely?

Note to Moderator: Limit the discussion only to unique methods/tools. Limit the time spent on this question.

W hat are the methods you use to ASSESS students' progress in learning math?

--Probe:

1. How do you keep track of how well the students are learning?
2. If you make notes (on paper or a spreadsheet) can you explain us how?
3. What are the limitation you feel in using this method for assessment

What kinds of performance indicators do you seek in assessing your students' progress?

--Probe:

1. Are these the same as the guidelines set up by the state of Georgia?

III. TEACHING MATH AND TECHNOLOGY (10 MINUTES)

Objective

To learn about the kinds of technology, if any, participants use when teaching math in their classrooms. Also to understand the features pre-K teachers are looking for in a device that helps them in the classroom while teaching math.

What kinds of technology, if any, do you use (or have used) in your classroom for teaching math and assessing student's math learning?

--Probe:

1. Are there examples where you think technology enhanced their teaching?
2. Do you have examples of failure?

Note to Moderator: Be sure to clarify that we're not specifically talking about computers as technology. By 'technology', we refer to a broader set of techniques and tools that could be used to augment teaching.

Would you be interested in having a (computationally-enhanced) device to help you teach math and assess students' progress in learning math?

--Probe:

1. What features, do you think, you'd like to see in such a device that can make learning better and enjoyable?
2. How, do you think, will your students react to a new device in the classroom?

Note to Moderator: Try to mutually create a wish list of features the teachers mention. These features may go beyond what's possible with today's technology.

If participants seem confused, move on to the next question.

IV. A POTENTIAL TECHNOLOGY FOR TEACHING MATH (20 MINUTES)

Objective

To gauge the reaction of the teachers towards this device, and to gain an understanding of how the teachers see using this device in their classroom environment.

Introduce the teachers to the general concept of the device –

1. The device helps children learn math by involving them in game activities like identifying numbers, counting and simple addition etc. The device gives step-by-step verbal and visual clues throughout the activity.
2. Instead of the regular mouse and keyboard input, the children play with physical blocks with numbers on them.
3. The device is a stand-alone, but the teacher can select activities for the children to play.
4. The device can keep track of student performance data.
5. Performance reports of individual students can be obtained at the end of the activities.

After being informed about this device, tentatively called "The Teaching Table," what are your initial feelings (reactions) about the device?

--Probe:

1. What are your opinions about how the students would feel about the device?
2. Would the device be engaging for the students?
3. How would it be better than current student experiences?
4. How would it be not as good as current student experiences?

How do you see yourself using the device in your classroom to TEACH math?

--Probe:

1. Ways in which you can include the device in present classroom activities?
2. How would it compliment/or not other math teaching methods?
3. How often would you use it? When?

<u>Note to Moderator</u>: This question may be skipped if time is running short.

When using the proposed Teaching Table, do you see it helpful in ASSESSING a student's performance in learning math?

--Probe:

1. What performance indicators would they seek in the performance results (time to complete activity, success rate, and highest level of activity completed etc.) to assess a child's progress?
2. What other data would you need?

What are your thoughts on whether or not the functions of the device will help you teach math in your classroom?

--Probe:

1. What's good about it? Any feature in particular that you liked?
2. Any feature in particular that you liked?
3. What could be improved?
4. Is there any feature missing that you would have liked to see included?
5. What should be taken away?

Note to Moderator: This question is open-ended. Various discussion issues may be encouraged depending on the time remaining. Also, the moderator/note-taker should answer any questions that the teachers might have concerning the technology.

VI. WRAP UP AND CLOSING (5 MINUTES)

We are just about out of time now.

Moderator should close the discussion and wrap up the session by doing the following:

1. Pose observer questions, if any;
2. Thank participants for participating;
3. Inform group that any additional comments can be forwarded to XX;
4. Officially end the group.

TOTAL PLANNED TIME: 60 MINUTES

appendix-IV

Ethical Standards for Research with Children
as described by *Society for Research in Child Development*

The principles listed below were published in the 1990-91 Directory, except for Principles 15 and 16, first published in the Fall 1991 Newsletter.

Principle 1: NON-HARMFUL PROCEDURES: The investigator should use no research procedure that may harm the child either physically or psychologically. The investigator is also obligated at all times to use the least stressful research procedure whenever possible. Psychological harm in particular instances may be difficult to define; nevertheless, its definition and means for reducing or eliminating it remain the responsibility of the investigator. When the investigator is in doubt about the possible harmful effects of the research procedures, consultation should be sought from others. When harm seems inevitable, the investigator is obligated to find other means of obtaining the information or to abandon the research. Instances may, nevertheless, rise in which exposing the child to stressful conditions may be necessary if diagnostic or therapeutic benefits to the child are associated with the research. In such instances careful deliberation by an Institutional Review Board should be sought.

Principle 2: INFORMED CONSENT: Before seeking consent or assent from the child, the investigator should inform the child of all features of the research that may affect his or her willingness to participate and should answer the child's questions in terms appropriate to the child's comprehension. The investigator should respect the child's freedom to choose to participate in the research or not by giving the child the opportunity to give or not give assent to participation as well as to choose to discontinue participation at any time. Assent means that the child shows some form of agreement to participate without necessarily comprehending the full significance of the research necessary to give informed consent. Investigators working with infants should take special effort to explain the research procedures to the parents and be especially sensitive to any indicators of discomfort in the infant. In spite of the paramount importance of obtaining consent, instances can arise in which consent or any kind of contact with the participant would make the research impossible to carry out. Non-intrusive field research is a common example. Conceivably, such research can be carried out ethically if it is conducted in public places, participants' anonymity is totally protected, and there are no foreseeable negative consequences to the participant. However, judgments on whether such research is ethical in particular circumstances should be made in consultation with an Institutional Review Board.

Principle 3: PARENTAL CONSENT: The informed consent of parents, legal guardians or those who act in loco parentis (e.g., teachers, superintendents of institutions) similarly should be obtained, preferably in writing. Informed consent requires that parents or other responsible adults be informed of all the features of the research that may affect their willingness to allow the child to participate. This information should include the profession and institution affiliation of the investigator. Not only should the right of the responsible adults to refuse consent be respected, but also they should be informed that they may refuse to participate without incurring any penalty to them or to the child.

Principle 4: ADDITIONAL CONSENT: The informed consent of any persons, such as schoolteachers for example, whose interaction with the child is the subject of the study should also be obtained. As with the child and parents or guardians informed consent requires that the persons interacting with the child during the study be informed of all features of the research which may affect their willingness to participate. All questions posed by such persons should be answered and the persons should be free to choose to participate or not, and to discontinue participation at any time.

Principle 5: INCENTIVES: Incentives to participate in a research project must be fair and must not unduly exceed the range of incentives that the child normally experiences. Whatever incentives are used, the investigator should always keep in mind that the greater the possible effects of the investigation on the child, the greater is the obligation to protect the child's welfare and freedom.

Principle 6: DECEPTION: Although full disclosure of information during the procedure of obtaining consent is the ethical ideal, a particular study may necessitate withholding certain information or deception. Whenever withholding information or deception is judged to be essential to the conduct of the study, the investigator should satisfy research colleagues that such judgment is correct. If withholding information or deception is practiced, and there is reason to believe that the research participants will be negatively affected by it, adequate measures should be taken after the study to ensure the participant's understanding of the reasons for the deception. Investigators whose research is dependent upon deception should make an effort to employ deception methods that have no known negative effects on the child or the child's family.

Principle 7: ANONYMITY: To gain access to institutional records, the investigator should obtain permission from responsible authorities in charge of records. Anonymity of the information should be preserved and no information used other than that for which permission was obtained. It is the investigator's responsibility to ensure that responsible authorities do, in fact, have the confidence of the participant and that they bear some degree of responsibility in giving such permission.

Principle 8: MUTUAL RESPONSIBILITIES: From the beginning of each research investigation, there should be clear agreement between the investigator and the parents, guardians or those who act in loco parentis, and the child, when appropriate, that defines the responsibilities of each. The investigator has the obligation to honor all promises and commitments of the agreement.

Principle 9: JEOPARDY: When, in the course of research, information comes to the investigator's attention that may jeopardize the child's well-being, the investigator has a responsibility to discuss the information with the parents or guardians and with those expert in the field in order that they may arrange the necessary assistance for the child.

Principle 10: UNFORESEEN CONSEQUENCES: When research procedures result in undesirable consequences for the participant that were previously unforeseen, the investigator should immediately employ appropriate measures to correct these consequences, and should redesign the procedures if they are to be included in subsequent studies.

Principle 11: CONFIDENTIALITY: The investigator should keep in confidence all information obtained about research participants. The participants' identity should be concealed in written and verbal reports of the results, as well as in informal discussion with students and colleagues. When a possibility exists that others may gain access to such information, this possibility, together with the plans for protecting confidentiality, should be explained to the participants as part of the procedure of obtaining informed consent.

Principle 12: INFORMING PARTICIPANTS: Immediately after the data are collected, the investigator should clarify for the research participant any misconceptions that may have arisen. The investigator also recognizes a duty to report general findings to participants in terms appropriate to their understanding. Where scientific or humane values justify withholding information, every effort should be made so that withholding the information has no damaging consequences for the participant.

Principle 13: REPORTING RESULTS: Because the investigator's words may carry unintended weight with parents and children, caution should be exercised in reporting results, making evaluative statements, or giving advice.

Principle 14: IMPLICATIONS OF FINDINGS: Investigators should be mindful of the social, political and human implications of their research and should be especially careful in the presentation of findings from the research. This principle, however, in no way denies investigators the right to pursue any area of research or the right to observe proper standards of scientific reporting.

Principle 15: SCIENTIFIC MISCONDUCT: Misconduct is defined as the fabrication or falsification of data, plagiarism, misrepresentation, or other practices that seriously deviate from those that are commonly accepted within the scientific community for proposing, conducting, analyzing, or reporting research. It does not include unintentional errors or honest differences in interpretation of data. The Society shall provide vigorous leadership in the pursuit of scientific investigation that is based on the integrity of the investigator and the honesty of research and will not tolerate the presence of scientific misconduct among its members. It shall be the responsibility of the voting members of Governing Council to reach a decision about the possible expulsion of members found guilty of scientific misconduct.

Principle 16: PERSONAL MISCONDUCT: Personal misconduct that results in a criminal conviction of a felony may be sufficient grounds for a member's expulsion from the Society. The relevance of the crime to the purposes of the Society should be considered by the Governing Council in reaching a decision about the matter. It shall be the responsibility of the voting members of Governing Council to reach a decision about the possible expulsion of members found guilty of personal misconduct.