ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

HEARING BLOCKS: A SYNESTHETIC SPATIAL SYSTEM PROPOSAL FOR CHILDREN

M.Sc. THESIS

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İSTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ

BLOKLARI İŞİTMEK: ÇOCUKLAR İÇİN SİNESTETİK MEKANSAL SİSTEM ÖNERİSİ

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Hande Karakaş, a **M.Sc.** student of ITU **Graduate School of Architecture** student ID **523121006**, successfully defended the **thesis** entitled "HEARING BLOCKS: A SYNESTHETIC SPATIAL SYSTEM PROPOSAL FOR CHILDREN" which she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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To the light of belief, the power of making,

FOREWORD

I would like to appreciate a few precious people who contributed to this study.

I sincerely appreciate to,

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Hande KARAKAŞ
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ABBREVIATIONS

DIY	**:** Do-It-Yourself
TUIs	**:** Tangible User Interface
VR	**:** Virtual Reality
IDE	**:** Integrated Development Environment

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HEARING BLOCKS: A SYNESTHETIC SPATIAL SYSTEM PROPOSAL FOR CHILDREN

SUMMARY

Children have more imaginative power than adults. They are able to transform objects and create related narrations in their daily expressions. When they match their cognitive and individual views, they interpret daily objects according to their own fiction. They see daily objects differently in their symbolic viewpoint rather than in their real function; therefore it is easy for them to transform functions.

It is already known that children are active builders of their own mediums. Yet current technologies offer confined spaces that children cannot actively participate in. Even if these spaces have easy accessibility, they are mostly inadequate for interacting due to their definite purpose. Screen-based devices are commonly used for supporting children's active participation in educational environments but do not provide bodily or spatial experience. The tactile relationship is essential for children to understand the object and its permanency and to be aware of their environment.

The thesis proposes a DIY (Do-It-Yourself) system that children can explore, imitate and through which learn. The system is for learning by doing in a multi-sensory environment where children are able to create their own rules and develop learning methods. As in synesthesia, the ability to perceive simultaneously two senses together, the proposed setup is devised to imitate the union of different senses and provides the user feedbacks in the interaction.

The setup basically consists of blocks and an embedded interactive system with which children synchronously can create formal and musical combinations. The block size are thought in sizes that 8-10 years old children can easily grasp and the interactive system is able to fit in. Each block is described with a unique musical note that activates by touching the block.

The experiments with blocks are conducted in the virtual environment to make further predictions. The process and the final products are modeled in the three-dimensional modeling program to examine which situations are created. Different formal situations and musical responses are investigated by adding, removing or repeating blocks. Therefore, both visual and audial feedbacks are considered constructive that enhance children's cognitive abilities.

BLOKLARI İŞİTMEK: ÇOCUKLAR İÇİN SİNESTETİK MEKANSAL SİSTEM ÖNERİSİ

ÖZET

Bir çocuğun hayal gücü yetişkinlerinkinden çok daha güçlüdür. Günlük eylemlerinde objeleri dönüştürüp öykülendirirler. Kendi bilişsel yetenekleri ve kişisel bakış açıları, günlük objeleri kendi kurguları doğrultusunda yorumlamalarını sağlar. Çocuklar objelere gerçek fonksiyonlarından farklı sembolik anlamlar yüklerler ve böylelikle nesnelerin fonksiyonlarını da dönüştürmüş olurlar.

Çocuklar halihazırda kendi araçlarının ve çevrelerinin aktif yaratıcılarıyken, günümüzde teknoloji bedensel olarak aktif katılamadıkları kısıtlı alanlar sunar. Kolay ulaşılabilir olsalar dahi, çoğunlukla belirgin amaçlarından dolayı etkileşim için yetersiz görülebilirler. Çocukların bedensel ve mekansal olarak deneyimleyemedikleri ekran tabanlı teknolojik sistemlerin, eğitsel çevrelerine katılımlarını desteklemek üzere yaygın olarak tercih edildiği görülür. Bu noktada, dokunsal arayüzlü üç boyutlu bir ilişkinin çocukları nesnelerle kalıcı ilişkinin kurulup çevresinin farkında olabilmesi için önemli olduğu öngörülmektedir.

Çocukların kendi oyun alanlarını kurmalarına imkan tanınmasıyla, yaparak ve keşfederek öğrenmeleri için zemin hazırlanmış olur. Aracın çocuğun etkileşimli sisteme erişiminin ve sistemi kavramasının kolay olacağı şekilde tasarlanması önemli bir husustur. Bu noktada, DIY teknolojilerinin bir aracı olarak gelişimi ve etkileşimli sistem geliştirilmesine yönelik tasarlanmasıyla çocukların yeni deneyimlere açık olmaları ve etkin bir öğrenme biçimi edinmeleri söz konusudur. Tez kapsamında, DIY (Do-It-Yourself/ Kendi Başına Yap) teknolojisi kullanılarak çocukların çok algılı bir ortamda keşfederek, uyarlayarak ve yaparak öğrenebilecekleri bir ortam sağlanması amaç edinilmiştir. Böylelikle çocukların kendi kurallarını koyup kendi öğrenme metotlarını geliştirebilecekleri bir sistem tasarımı hedeflenmiştir.

Farklı duyuları eş zamanlı tetikleyen etkileşimli sistemin geliştirilmesi ele alındığında, sistemin çocukların nesneleri ve çevresini yorumlamalarını olumlu yönde etkileyebileceği öngörülmektedir. Sinestezideki farklı duyuların eş zamanlı uyarılması baz alınarak çocukların yaratıcılıklarının ve yorum yeteneklerinin geliştirilmesi esas alınmıştır. Bu doğrultuda önerilen kurulum, farklı duyuların birleşimini taklit eden ve kullanıcı geri bildirimini sağlayan interaktif bir sistem olarak tasarlanmıştır.

Kurulum, Froebel bloklarından esinlenilerek tasarlanmış bloklar ve blokların içlerine yerleştirilmiş etkileşimli sistemlerden oluşur. Bloklar 8-10 yaşında bir çocuğun eliyle kavrayabileceği büyüklükte ve etkileşimli sistemin içine yerleştirilebileceği ölçülerde, ahşap malzemeden tasarlanmıştır. Sistemin taşınabilir setler halinde üretilmesi öngörülmüştür. Böylece sistemin mekansal olarak kullanımında farklı alternatifler sunulup öğrenmenin yaygınlaşması ve mekansal olarak kolay ulaşılabilirliği sağlanmış olacaktır.

Dokunma, öğrenmede etkin bir duyu olarak çocukların objelere dokunmayla etkileşiminde, objeyi tanımlamalarında ve süreci hafızalarına almalarında aktif rol oynar. Tasarlanan bloklar farklı geometrik biçimler olarak düşünülmüş olup, blokların içindeki interaktif sistem dijital arayüzde programlanarak her birine farklı notalar atanmıştır. Çocukların farklı biçimsel ve müzikal kombinasyonlar oluşturabilmeleri için kurgulanan her bir bloğa atanmış olan notalar bloklara dokunmayla aktif hale gelmektedir. Bloklarla temasa geçildiğinde ortaya çıkan sesler, bloklar için oluşturulan platformun içindeki sistem tarafından kaydedilmektedir. Kaydedilen ses tekrar dinlenebilir olup böylelikle sürecin işitsel geri bildiriminin sağlanması planlanmıştır.

Bloklarla yapılan deneyler, öngörüler kazanma amacıyla sanal ortamda yürütülmüştür. Farklı durumları irdelemek için süreç ve sonuç ürünler üç boyutlu modelleme programıyla sanal ortamda modellenmiştir. Blokların eklenmesi ya da çıkarılmasıyla oluşan farklı biçimler ve biçimsel durumların karşılığı olan müzikal çıktılar incelenmiştir.

Önerilen sistemde geri bildirimlerin çocukların bilişsel yeteneklerini geliştirmesi için yapıcı olacağı öngörülmektedir. El-zihin kordinasyonunu kullanarak eş zamanlı müzikal etkileşimi sağlayan sistemin çocukların işitsel algılarının ve müzikal yetilerinin gelişmesinde etkili olması beklenmektedir. Görsel ve işitsel yetilerini kullanmaları çocukların duyudevinimsel gelişimleri açısından önemli olduğu düşünülmektedir.

1. INTRODUCTION

Children have the ability to create their own tools and playscape in their daily life. In her "*Tools for Constructive Learning: Rethinking Interactivity*", Ackermann (1993) states that children are active builders of their environment as world makers. Children's relationships with daily objects as their tools promote understanding of children's natural environment and creating their playground on their own. On the other hand, providing new tools pushes children to think in new directions. Criterias on designing new tools for children might be specified to motivate children in a specific context without any restriction on their vivid imagination.

"Low threshold" and "high ceiling" definitions for tool design (Myers *et al.*, 2010) are utilized in this study. The "low threshold" means easy accessibility and adaptability without the difficulty of tools, while the "high ceiling" represents the performance and the supportability of the creative thinking via tools. Addition to these, a definition for "wide walls" is introduced to emphasize that tools should give the opportunity to broadly explore (Resnick *et al.*, 2005).

When viewed within the context of these three definitions, current technologies restrict the development of children's cognitive and spatial abilities. Technological tools are often screen based and offer non-physical connection rather than bodiliy pariticipation. To remedy this restriction, the thesis explores multiple sensations and offers easy access to children through system supported by DIY technologies that are designed in order to build children's own medium in a defined context and to create their own playscape.

The study frames different notions of learning, play and sensation. The learning is placed as a general look at how it is possible to effectively improve children's learning abilities. Hereby, play is supposed as the most influential medium for learning. The relationship with objects in a play forms the activity as didactic as touching comes to the fore in recognition and memorization.

According to this, inventing new tools enables children to tangibly project their visual representations and imagine without any restrictions or pre-defined rules. By providing such grounds, children develop symbolic thinking and synchronously benefit constructive and creative perspectives to their imagination. However, interaction with objects in play provides feedbacks to children during the activity where a trial-error mechanism supports the active learning process.

Considering these, a system is proposed and designed as a movable DIY kit to spread the approach and learning activity where no certain place for learning is specified (Ackermann, 2012). Synesthesia is considered as the basic principle of the DIY system to develop a sensory environment for children and is also considered to incubate the creative process in the physical environment.

2. DESIGNING FOR CHILDREN

In this study, I suggest an interactive spatial system, which simultaneously triggers different senses and provides synchronous interactive user-feedbacks. The aim is to install an interactive prototype that imitates the association of different senses as in synesthesia (Figure 2.1). Therefore, an experimental ground is provided for children to learn through play, one with different geometries, and constant visual, spatial and sound elements to simultaneously enhance children's aural and spatial abilities.

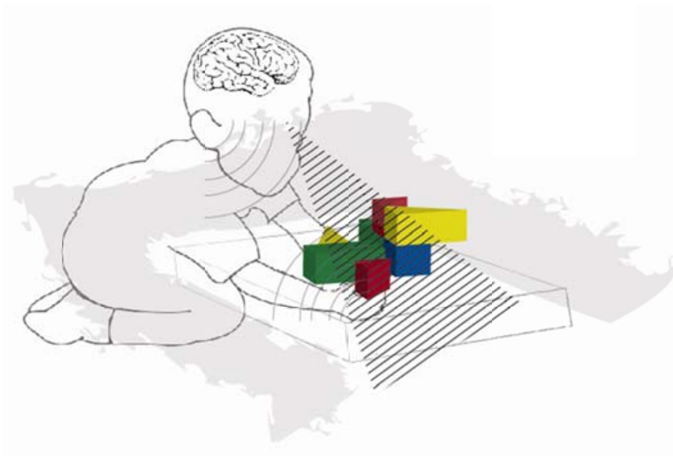


Figure 2.1 : The sensorial environment in the system design (by the author).

In the proposed prototype, children are able to synchronously experience formal and musical compositions through hand gestures. Based on the logic of Froebel's wooden blocks in his series of "gifts", a new set of blocks is designed with a new approach. Newly from Froebel's blocks, blocks are supported by DIY technologies to create a multi-sensorial environment. Blocks are shaped in different geometries such as cube and rectangular prisms as it will be stated in detail in next chapters.

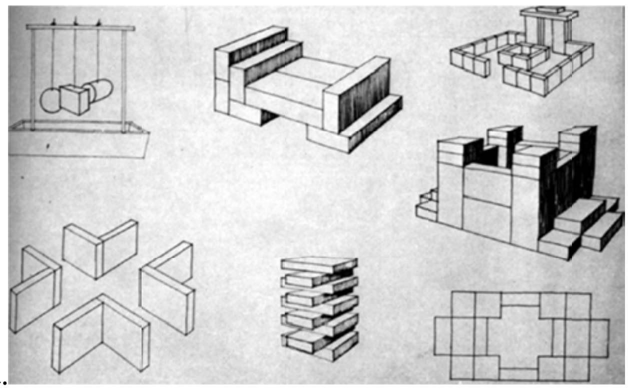
Each block corresponds with different musical notes that children interact with the output sound and produce children's own simultaneous figural compositions. Thus, children find the opportunity to construct their own language in a physical format that produces musical strings. Recording and playback of sounds are took as another crucial baselines that provide the continuity of interaction (Ackerman, 1993). In the study, different situations with blocks are simulated in a digital environment to make predictions.

2.1 CHILDREN AS ACTIVE BUILDERS

Children are active learners as they build their own language and knowledge in their natural environment. Through learning by doing, children have the ability to create their own playscape everywhere and manage their own processes. In play, as a mediator of learning, the hand-mind correlation might be seen significant to provide interaction with objects. In the cognitive aspect of that interaction, “touch” plays a major role to recognize the objects and obtain information from the whole process.

2.1.1 Learning and Play

So far in history, different arguments come to the fore as theories of play on whether it is an intermediate activity of learning or not. It is known that in ancient Egypt, arithmetic games are provided to children in order to engage their attention to learning while playing. Plato states this in *the Laws* (1509) to indicate play as a method of education. In due time, there are different initiatives upon learning in play such as Froebel’s. Froebel puts play at the center of learning and invents a series of play kits named “gifts” (Fass, 2004). The kits enable children to experiment with different geometric blocks in different geometric combinations (Figure 2.2).



a.

b.

Figure 2.2 : Froebel blocks: **a.** Drawing of different combinations (URL-1), **b.** Manufacture of wooden blocks as kits (URL-2).

Children as active learners define goals and try to reach them while mediating the play with objects as their tools. Children enhance techniques “doing as if” and “playing what if” to balance the trial-error process (Ackermann, 2004). With these techniques, children imitate as if objects are a figment of children’s imagination and play what if they behave differently to discover the next step. Hereby, the pretense play is triggered that enhances their intuitive knowledge.

2.1.2 Learning Everywhere

There might be no certain place for children as they begin to play, especially when they find the way to learn things in their natural environment. Their imaginary world is open to think freely and experience without any pre-defined rules in their natural environment. Physician and educator Maria Montessori, conducts experiments with children that they are able to act freely in a self-controlled environment. Montessori (1992) argues that when the chance of correcting and controlling children’s own mistakes is given to children, a didactical environment is already provided without any need of observations from outside. In the proposed system, creating such atmosphere for children is aimed to give them freedom in a framework.

According to Ackermann (2012), “the edgeless school” broadens the scope of being educated. However, she argues how it might be possible to go beyond educating in certain educational places and adds the current technology factor to it. Moreover, she reminds that ‘the edgeless’ does not mean the ‘formless’ to emphasize the significance of defining context. In terms of giving form to the activity, the proposed system is considered as movable kit to make the activity independent from a certain place. In the study, the independence is provided with current technology, therefore, children can adapt in any place with the proposed tool. However, the designed system alone carries the potential to spatially transform the children’s environment. Figural compositions that children make with designed blocks set different spatial characteristics. Therefore, the system is supposed to carry these spatial properties within wherever it is installed.

As a related issue, portable DIY kits are considered as proper systems for children that are already assigned as makers of their own environment. DIY kits are transportable and easy accessible, therefore, learning is not only obligated in educational institutions but also provided as continuous and open version.

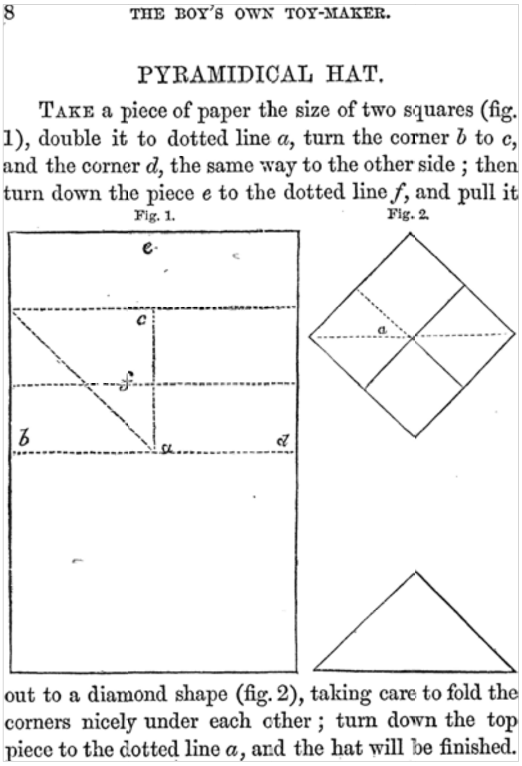
2.1.3 Hands On: DIY Systems

Children are makers of their own world and have the ability to craft their own tools to establish themselves as individuals in children's environment. While providing a base to adapt children to the activity, it is essential to support with instructions in order to frame the process as didactic. At this point, DIY systems are developed for children to build the system on their own within the context of instructions.

2.1.3.1 Manual to Digital

In *Communities of Practice Learning* (2012), the educational theorist Étienne Wenger emphasizes that the nature of the activity changes according to tools. Diverse tools for children mediate the activity as children can adapt to different environments.

In the history of children's play, the 19th century is considered initiative with manual examples of DIY mediums for children. In this era, books are published that guide children manually make their own toys (Fass, 2004). These books are considered as recreational activities for children's leisure hours while also provide learning by doing. For instance, "the Boy's Own Toy-Maker: A Practical Illustrated Guide to the Useful Employment of Leisure Hours" by Ebenezer Landells, published in 1866, includes several instructions that guide children to how to make toys such as kites or hats on their own (Figure 2.3). The proposed system is influenced with such manual mediums that children can learn by doing that enhance children's creative abilities.


8 THE BOY'S OWN TOY-MAKER.

PYRAMIDICAL HAT.

TAKE a piece of paper the size of two squares (fig. 1), double it to dotted line *a*, turn the corner *b* to *c*, and the corner *d*, the same way to the other side ; then turn down the piece *e* to the dotted line *f*, and pull it

Fig. 1. Fig. 2.

out to a diamond shape (fig. 2), taking care to fold the corners nicely under each other ; turn down the top piece to the dotted line *a*, and the hat will be finished.

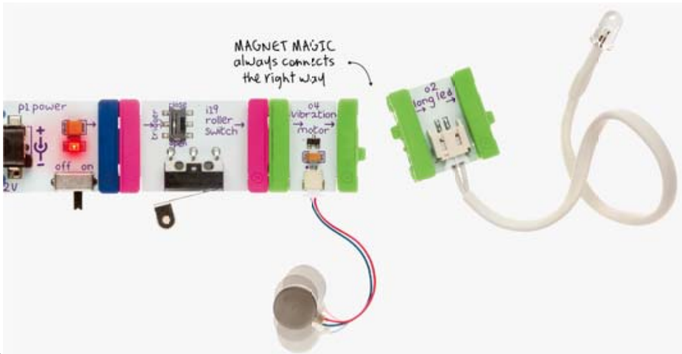
Figure 2.3 : Instruction for making pyramidical hat, “The Boy’s Own Toy-Maker: A Practical Illustrated Guide to the Useful Employment of Leisure Hours”, (Landells, 1866).

At this point, technology enriches the development of tools for children in the digital realm. DIY technologies promote children acquiring active learning and provide openness to new experiences. Thus, children obtain different information by experiencing via different media and tools.

2.1.3.2 DIY Systems for Children

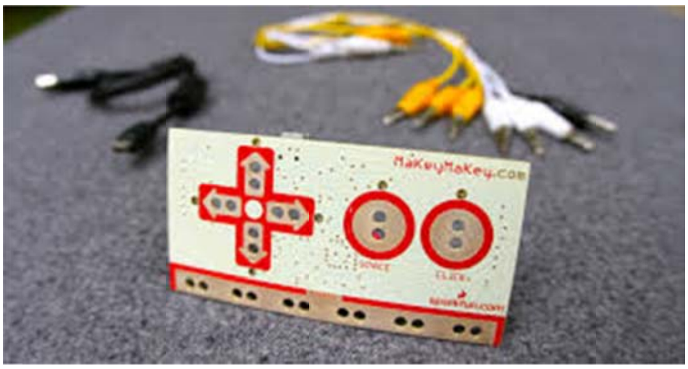
A mental model is already defined in the individual’s mind to use, understand and remember in a tangible contact with objects. Thus, the interaction through surfaces of the objects (TUIs-Tangible User Interfaces) has an impact on more dynamic relations with the memory. (Mugellini *et al.*, 2007) DIY systems are examples that may include both manual and digital interfaces. In this respect, it is possible to say that tangible DIY systems have a strong influence on learning.

Littlebits, *Primo*, *makey makey* are examples of DIY systems that explain the interaction with such haptic interface. (Figure 2.3) DIY systems that are enhanced with current technologies as “tools to think with” just as Seymour Papert’s “Turtle Geometry” was years ago, is at the top of the agenda. *Primo* and *makey makey* take as the principle of "Turtle Geometry". The 'Turtle Geometry' basically works with basic commands depending on analytic orientation that uses turtle as a cursor. Through these systems, teaching the basic logic of programming is aimed that simultaneously gives the possibility to children to create their own playground. *Littlebits* is a modular system based on working principle of Arduino with a simple input-output connection. Therefore, children are able to connect basic electrical circuits to develop their projects. These examples are reviewed in order to picture how various DIY systems for children are developed and enrich their imagination.



a.

b.



c.

Figure 2.4 : Examples for tangible DIY systems: **a.** Littlebits (URL-3), **b.** Primo (URL-4), **c.** makey makey (URL-5).

2.1.4 Learning by Touching

"Touch" might be mentioned as a crucial sensation in terms of actively exploring and obtaining information from objects. Recognizing objects basically depends on two modes of perception, which are vision and touch (Gibson, 1962). The figure-ground principle in the visual perception evokes the recognition of object contours. On the other hand, both back and front surfaces of the object are recognized by touch, differently than vision (Figure 2.5). Gibson adds that both senses operate synchronously together for the success of full recognition.

Figure 2.5 : Object recognition with tactile, (URL-6).

At this point, contours are considered as the key point for design of the proposed system in terms of recognizing objects. Hereby, contours of designed blocks are envisioned as borders for a multisensory transition.

As popular tools of recent years, touch screen tablets may be considered as inadequate in providing good connections on three-dimensional realisation with multiple senses. At a first glance, "touch" is an active sense in use of screen-based tablets; in fact, the overall sensation is mainly provided by vision. It is asserted that touch screen tablets utilize literacy learning for children such as alphabet learning and writing (Neumann *et al.*, 2014). But three-dimensional realization disappears and the experience is restricted with click or drag-drop motions. From this angle, it can be said that the three-dimensional feeling by "touch" is essential in order to provide objective connections. "Touch" provides the continuity of understanding and might be thought as the backbone of learning by doing. In the proposed system too, three-dimensional touch and vision are utilized together to obtain the information from the activity.

2.2 CHILDREN AS DREAMERS

Play is a mediator activity in which children are able to create their own playscape. In play, any object has a potential to be transformed by children's vivid imagination as visual representation of their mental imagery. Children's pre-known behaviors emerge as the imitation and objects are thought as mediums to trigger pretense play.

2.2.1 Symbolic Meaning in Play

Play first emerges in the verbal negotiation with the shared knowledge of the adults in play (Fass, 2004). In the object-children relationship, children rearrange functions of objects and give symbolic meanings to them during the play. Therefore, play paves the way for them to link the reality to the imitation with the transposition of the symbol. As children start their imaginative play, no limitations or pre-defined rules appear in their symbolic view (Piaget, 1962).

A chair as an example is possible to be transformed into another function rather than real function of the chair in children's own imagination (Kay, Karakaş, Özkar, 2015). Children may transform its concave-enclosed structure into their habitat to spare themselves a private place and they construct their own imaginary walls or roof of the house (Figure 2.6). According to Swiss psychologist Jean Piaget (1962), in such symbolic schemas that explain transformability of the objects in the play, the chair (the present object) is defined as "signifier", which symbolically "signified" the absent object as a house for children. Hereby, the symbol depends on the resemblance of this two.

Children's imaginative power of imitating objects considered as a potential benefit for the proposed system too. Therefore, children are expected to develop diversity in combinations with blocks by using the potential.

Figure 2.6 : Children playing around a chair, (Charles Petit, 19th Century) (URL-7).

2.2.2 Interactivity in Play

Within the absent-present relationship of transforming symbolic meaning of objects, two more acts are indicated as giving form to ideas and making them concrete (Ackermann, 2004). At this point, interactivity comes to the fore in order to provide the continuity of making ideas concrete. Considering tangibility in the interactivity, constant feedbacks affects the further step that children fictionalize in the play. However, tangible interaction, which each movement in the play is hidden in traces on objects, supports memorability (Ackermann, 1993). Such tangible interactions promote learning in play from the point of making changes according to feedbacks and memorizing.

Montesorri (1909) mentions that the self-correction of errors is significant in the interaction with objects during the play. The trial-error method enables children to learn correcting mistakes on their own by the balance of "doing as if" and "playing what if" operations that triggers pretense play (Ackermann, 2004). Hereby, children find the way to develop their own techniques to struggle with problems that children encountered, find the opportunity to individually introduce themselves in their own playground.

At this point, interactivity emerges as an enabler to the continuous flow of the information. Ackermann introduces five different leverage points for interaction as "transformation", "immersion/point of view", "verisimilitude", "locus of control" and ”perceptual/symbolic modalities”. The last one, “perceptual/symbolic modalities”, are explained best through VR (Virtual Reality) technologies, where senses attend to the activity, and have the critical in any interaction.

2.3 CHILDREN AS PERFORMERS

Human body establishes a constant connection with the external world through senses. Data in a variety of details is received by the senses from the external world while a continuous flow of information is provided to the brain. Therefore, objects are experienced through the senses and environmental data is possible to be interpreted.

2.3.1 Synesthesia

Synesthesia is defined as union of senses that one sense stimulates automatically the other sense in mind. Therefore, mentally evocation occurs in different sensory domains (Evers, 2011). For instance, a synesthete might see colors in letters or believe to be hearing colours that commonly appear as the union of dual senses.

In the example of the creative process of artists such as Kandinsky, the positive effect of synesthesia has been argued in several sources, even though that might not be asserted for every human being. Based on Kandinsky, for example, synesthesia has been argued to explain the relationship between art and sensations (Iona and Tyler, 2003) (Figure 2.7). It is possible to assert that creativity might be influenced with synesthesia, at the point, where association provides the continuous connection between senses.

Figure 2.7 : Bild mit rotem fleck, (Kandinsky, 1914) (URL-8).

In this regard, the union of senses and interpretation can be considered as a mean of expression by art and a key consideration in the context of incubating the creative process. Through these, one synesthete subject of neurologist Richard Cytowic's experiments, namely MLL, (2002) might be an instructive example who sees shapes in colors.

> MLL When I listen to music I see colored shapes. If I am tired at the end of the day the shapes seem very near. They are always in color. Shiny white isosceles triangles, like long sharp pieces of broken glass. Blue is a sharper color and has lines and angles, green has curves, soft balls, and discs. It is uncomfortable to sit still. I feel the space above my eyes is a big screen where this scene is playing. (9/2/85) (Cytowic, 2002, p.28)

In diagnosis of synesthesia, Cytowic (2002) itemizes memorability as one of five features. The reason is the close relation between synesthesia and hypermnesia, which means retentive memory and recall of the past. Therefore, synesthesia is used in mind as mnemonic aid due to their accompanier with every sense and later recognizing object seems easier through this. That might evoke a continuous flow of different data to the brain that results in recalling them to make creative combinations.

In the study, synesthesia is imitated to promote creativity and memorability. Union of senses is considered crucial to enrich perceptual fiction of children. Different senses as touch, vision and audition commit with designed blocks to provide multi sensory environment.

2.3.2 Education of Senses

As Ackermann emphasizes that the 'edgeless' does not imply formlessness, physicist Édouard Séguin's method forms a frame in recognizing objects and makes children examine activity through objects. In education of senses, Séguin asserts three periods in recognition of objects, which are defined as:

. Associating a sensory period with a specific name

. Recognizing object with this name

. Recalling the name and recognizing the object (Montessori, 1909).

By doing so, different senses are evoked and memorizing gets easier on recognizing objects with another accompanier sense. In the proposed sytem, evocation reflects as defining each block with a specific sound. Therefore, blocks can be recognized with multiple senses.

Montessori, in her experiments with children, uses different geometric sets to examine how children approach objects with the visual-tactile and muscular perception (1909). She defines three different cards, which have different characteristics in their contours and fillings (Figure 2.8). In the second set, which contours of geometries are more certain than the first examined ones, she observes that the child first follows the contours with his finger as the movement is guided by his eyes. In the later step, the child remembers the movement and the geometry and therefore is able to switch form concrete to abstract. By preparing such grounds to children, their sensibility is aimed to enhance in the direction of intellectuality that prepares them to be individuals in their natural environment.

Referencing to Montesorri's experiment, in the proposed system too, contours of geometric blocks are considered to activate system by touching and to recognize the geometry of the blocks with the corresponded sound.

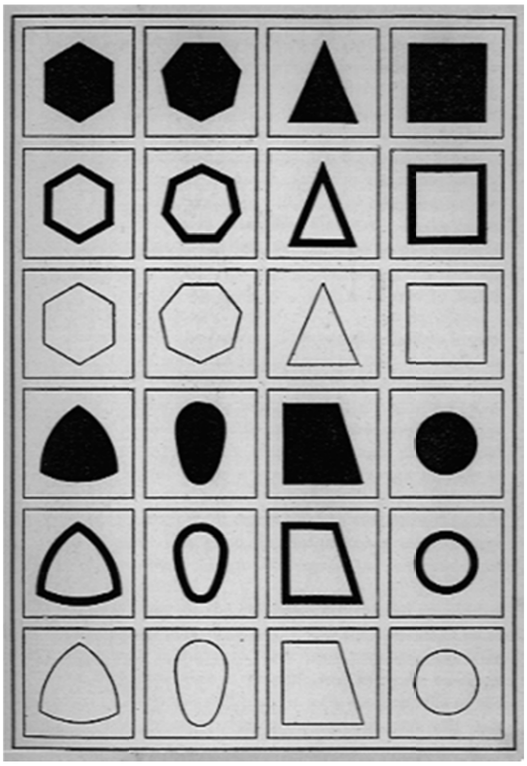


Figure 2.8 : Different geometry contours and fillings that Montessori used in her experiments with children (p.186) (1909).

3. IMPLEMENTING A SYNESTHETIC SYSTEM

3.1 Learning From Bodies, Objects and Silhouettes

As a preliminary study, Kay, Karakaş, Özkar (2015) developed an interactive setup that allowed for children to experience with live video feed in creating playscapes. In that collaborative project, blocks took part in interacting with video image viewed on the screen. The section below is a summary of the relevant details from the paper.

The system basically captures children's bodily movements during the play, however, gives the opportunity to interact with their own playmate as a silhouette in the screen. As a result of this, it is expected to accommodate a new playscape for children with a new defined digital realm while creating their own play in their natural environment. In the scope of the study, a DIY system is suggested in which children are bodily active by setting their own rules, therefore, making inferences is possible through children's creative use of digital and physical mediums.

In the setup, Kinect is preferred as a motion-sensing device to conduct the data captured from body movements in the physical environment. The physical data is converted with the written code on Processing software that converts physical data into silhouettes on a projection screen (Figure 3.1).

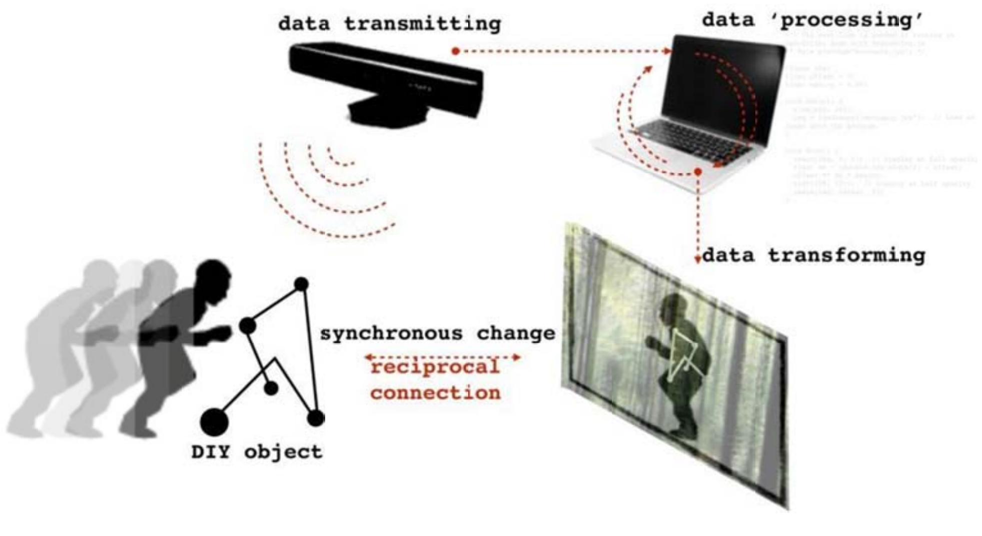


Figure 3.1 : Diagram of the technical setup, (Kay, Karakaş, Özkar, 2015).

In the setup, different silhouettes with objects are possible to be displayed on the screen by using Boolean subtraction and union of shapes (Figure 3.2). By these operations, different colours or patterns are able to be assigned on silhouettes. For example, a different colour might be observed on the shape of intersected silhouettes on the screen, or different background image is possible to be assigned to simulate an artifical void.

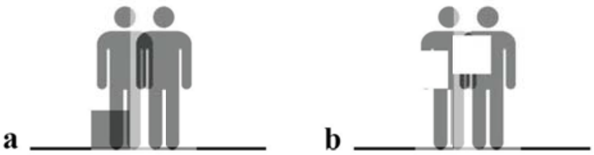


Figure 3.2 : Boolean operations on silhouettes: **a.** Union, **b.** Product/Subtraction, (Kay, Karakaş, Özkar, 2015).

Figure 4.1 : In Figure 3.3, two different positionings of user, object and the sensor are observed. Visibility of the body changes according to the positioning of user and object. However, object is included to the silhouette of the user whether it touches to the body or not (Figure 3.4). This selective invisibility is considered as a crucial feature for children to set their own rules in a absent-present relationship.

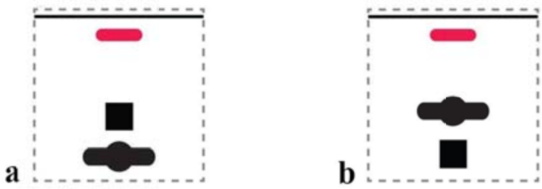


Figure 3.3 : Two different positionings of user, object and the sensor: **a.** User behind the object, **b.** User in front of the object, (Kay, Karakaş, Özkar, 2015).

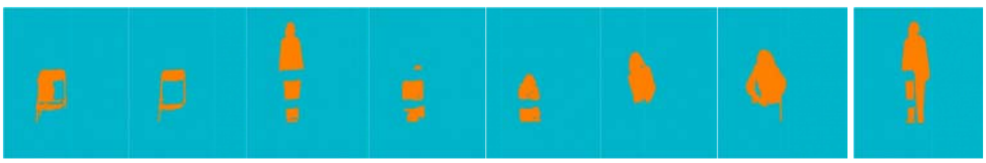


Figure 3.4 : Exploring visibility and invisibility through interaction with the object: The chair is subtracted, (Kay, Karakaş, Özkar, 2015).

The study established a precedent for how children may relate to blocks with bodily experience in a sensorial environment (Figure 3.5). In the setup, each physical modification on object response with different visual outputs that children can establish connections between his/her body and eyes. As direct results of children's movements, an active interaction is provided by the platform which also supposed to engage with the active learning process. In the direction of feedbacks from the image on the screen, interpretation of children's own movements with blocks provides a dynamic relations between seeing and doing. At this point, designing blocks comes to the fore as the next step of this study to create a multi sensorial environment and provide new medium for children with a new perspective.

Figure 3.5 : The intersection of the silhouettes changes into the color pattern of the objects, (Kay, Karakaş, Özkar, 2015).

3.2 The Design of the Synesthetic System

The proposed system is installed in both physical and digital environment. The physical infrastructure is the design of the tangible interface as blocks and the installation of the interactive board system. The digital interface is the related part of programming the interactive board that physically integrated to the blocks.

3.2.1 Physical Infrastructure

In the study, objects that mediate the activity are divided into three different scales according to the relationship between mind and body movements (Kay, Karakaş, Özkar, 2015). The first one is defined as small-scale objects that can easily be modified by hand. The second is mid-scale objects that require different body movements to modify such as moving, leaning, sitting. The third is larger-scale objects, which surround children. In this study, small-scale objects are chosen that are easily graspable by hand by 8-10 years old children. Four different forms such as cubes, rectangular prisms, and triangular prisms are considered as geometric blocks, which is possible to diversify in the further studies (Figure 3.6).

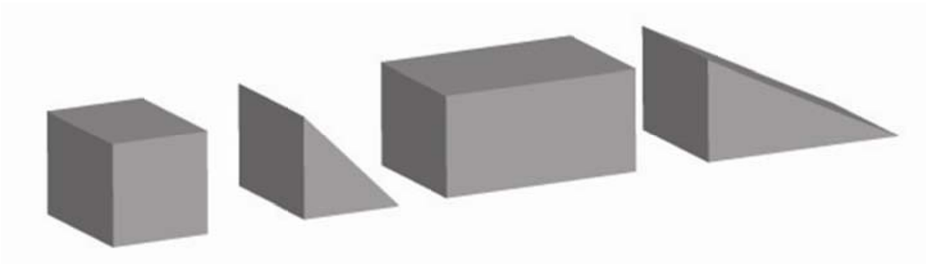
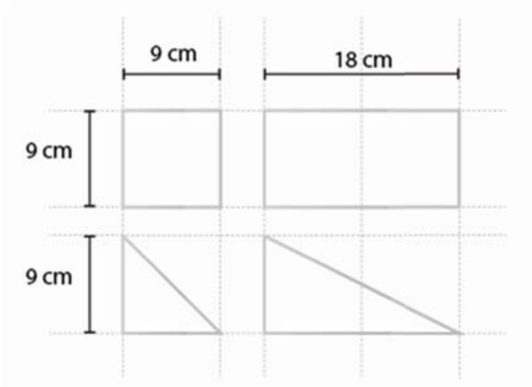


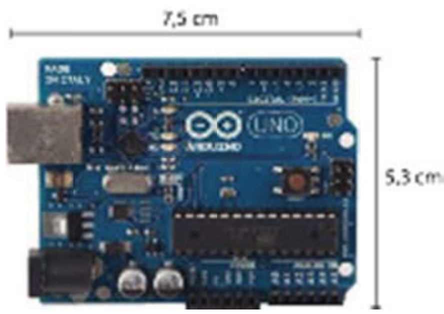
Figure 3.6 : Geometric forms used in the study, (by the author).

The DIY system is produced by Arduino Uno, which is designed as a learning platform. As a programmable platform, Arduino Uno creates interactive objects and sensorial environments by converting different physical inputs into various outputs, thus it enables manufacturing kits.

As the dimensional criteria, triangular prisms are proportionally thought as half of the cube and rectangular prism volume, therefore, different patterns are considered as easily measurable according to this ratio and proportion in a basic logic. The shortest edge of the geometric blocks is 9 cm in order to install Arduino into blocks according to dimension of Arduino Uno (Figure 3.7).



a.



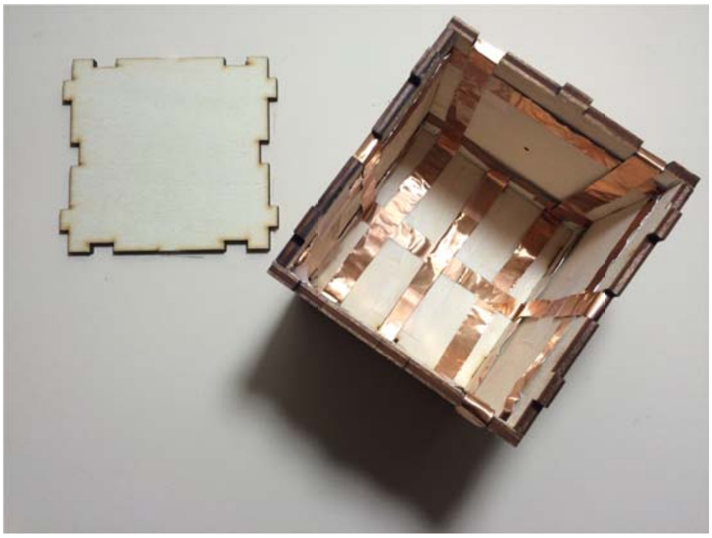
b.

Figure 3.7 : a. Dimensions of geometric forms used in the study, **b.** Dimensions of the Arduino (URL-9).

According to a common sensor classification, sensors are divided in three according to their physical quantities such as the application (temperature, pressure…), the output (active, passive…) and the measurement (resistive, capacitive, inductive…) (Singh, 2009). In the study, the capacitive sensor, which works with capacitive coupling, is taken as the principle in order to supply the conduction with the human body capacitance. In the capacitive sensor, ink, copper and aluminum folio are generally used for sensing materials. In the setup, cables are connected with a metal surface, as it completes the loop of the electrical circuit. Therefore, touching the block triggers the system via the metal strips.

The installation of the interactive system is shown in Figure 3.8. After the fabrication of surfaces of blocks with the laser cutter machine, the internal system is built. First, the metal strips are located on a grid, which is specified on axes of tongue-and-groove joints. Finally, the Arduino setup is installed and surfaces of the block are interlocked.

a. 

b. 

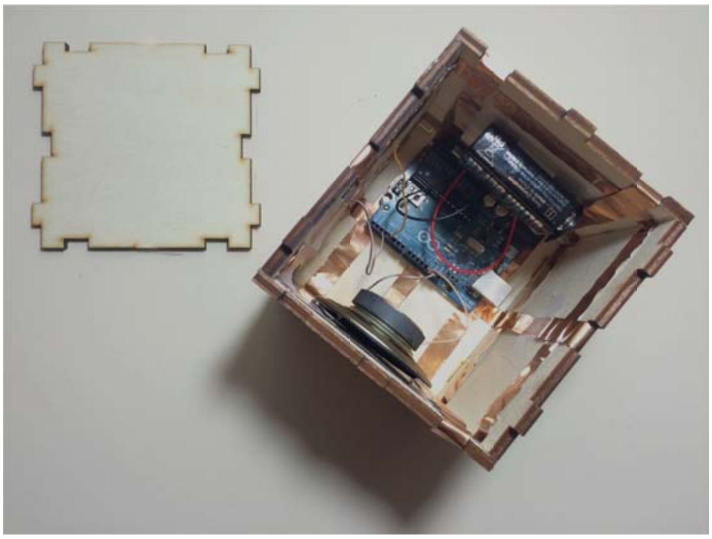
c. 

Figure 3.8 : Installing the interactive system into the block: **a.** Fabrication of the wooden surfaces, **b.** Installing metal strips, **c.** Installing the Arduino setup (Arduino Uno, Battery, Speaker, and Cables).

The Arduino setup is schematically shown in Figure 3.9. The system in the blocks includes a speaker exuding the sound from holes on the surface. The battery provides the power supply of the system, however, two cables connect with the conductive material that triggers system by touch. In Figure 3.10, working principle of the electrical circuit is seen that declares how data processes in the Arduino setup.

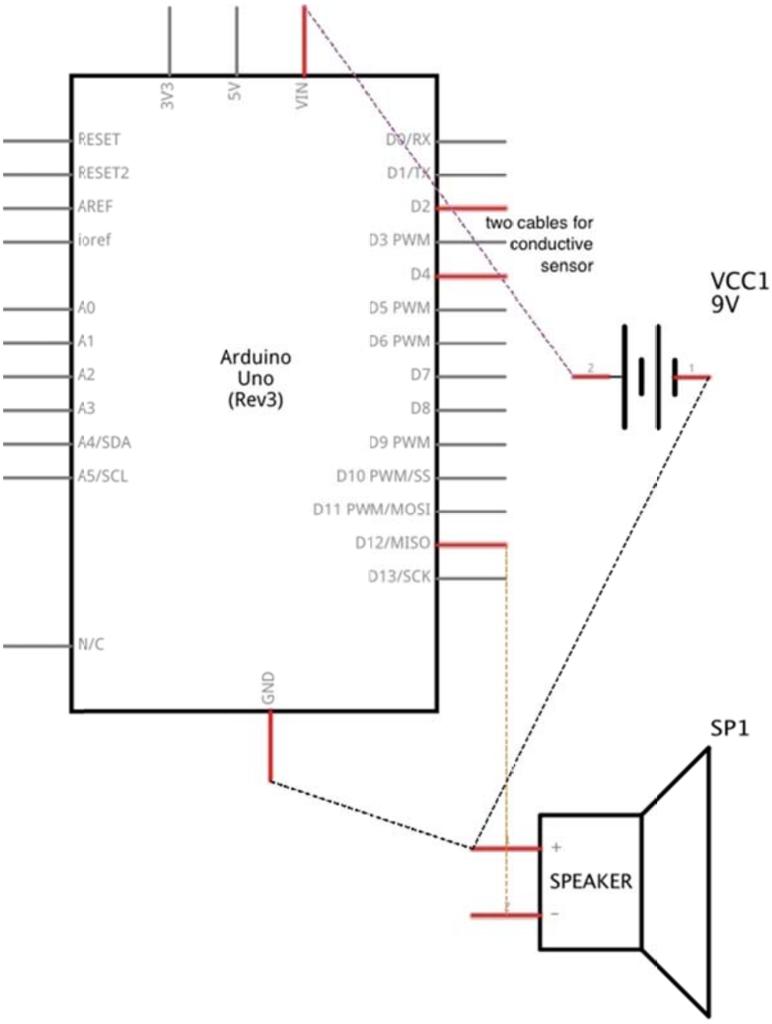


Figure 3.9 : Schematic diagram of the Arduino setup, (prepared with Fritzing).

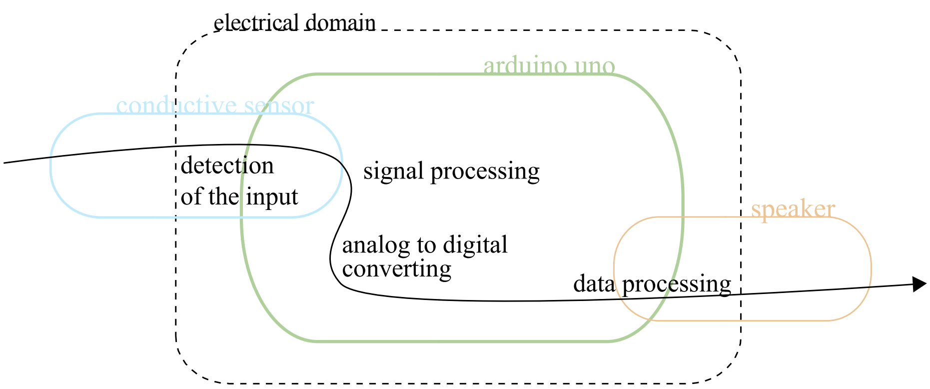


Figure 3.10 : Working principle of the electrical circuit, (by the author).

The surfaces of the blocks are connected with an interlocking system to easy access the internal part of the block; therefore, fixing is easier at the time of any failure in the system due to the demountable structure. At tongue-and-groove joints, there are some blanks on the edge of surfaces in order to reach the strips inside that complete the circuit by touch (Figure 3.11). The material of the interlocking surfaces is chosen as plywood; hereby it is considered that tactile sensing is provided with a natural material that contains no harmful content.

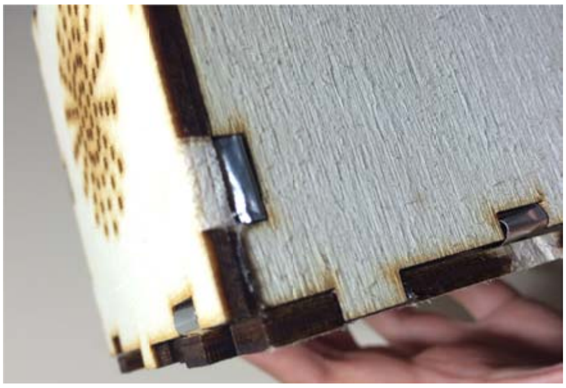


Figure 3.11 : Tongue-and-groove joints of plywood surfaces and conductor material on the edges of the blocks.

The blocks are planned to be placed on a platform that absorbs and records the sounds from blocks later give the output as playback (Figure 3.12).

Figure 3.12 : Plywood platform absorbing the sound from blocks.

3.2.2 Digital Interface

In the programmable interface of the Arduino, called IDE (Integrated Development Environment), the environment has a language written in JAVA. The digital interface converts the data taken from the external media into its own language and interprets according to the code string. Then, the interpreted data of the input through the code emerges as different outputs in the physical environment. The basic principle is shown in Figure 3.13 that explains the system triggering by touching.

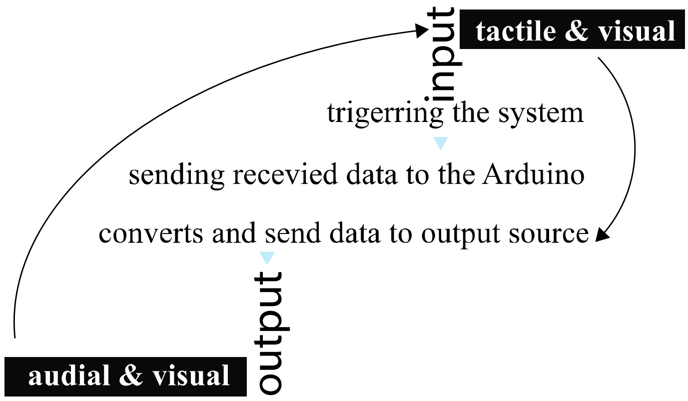


Figure 3.13 : Sensory input-output, (by the author).

Various libraries defined in Arduino IDE give the opportunity to use different sensors with the board. However, through these libraries placed in Arduino IDE and the other open source libraries on websites give the opportunity to understand the logic of the different codes and make combinations to create unique projects as desired.

The conductive sensor method completes the circuit by touching. As touch is an effective mediator of learning, this method is appropriate for the written code process. Capacitive sensor method in Arduino IDE is already defined that is called from the library of Arduino. The code in the project is based on this method. The basic description of the algorithm is: first define which pin is for conductive material and which pin is for the speaker as an output mediator; then if the threshold value is smaller than the sensor value, play the determinated tone and delay in the given value. (Figure 3.14)

```
// Arduino/libraries directory)
#include <CapacitiveSensor.h>

// pin 4 sends electrical energy and pin 2 senses senses a change
CapacitiveSensor capSensor = CapacitiveSensor(4, 2);

// threshold for turning the lamp on
int threshold = 1000;

// pin the speaker is connected to
int Buzzer = 12;

void setup() {
 // open a serial connection
 Serial.begin(9600);
 // set the speaker pin as an output
 pinMode(Buzzer, OUTPUT);
}

void loop() {
 // store the value reported by the sensor in a variable
 long sensorValue = capSensor.capacitiveSensor(30);

 // print out the sensor value
 Serial.println(sensorValue);

 // if the value is greater than the threshold
 if (sensorValue > threshold) {
   // play the tone
    tone(Buzzer,400,200);
    delay(100);
 }
}
```

Figure 3.14 : The Algorithm used in Arduino IDE, (by the author).

3.2.3 Budget of the System

Material and technology of the proposed system are preferred considering low budget in terms of accessibility and spreading the system in a wider area. Blocks and the platform are made of plywood. The no value added cost of material and the laser cutting process is 150 TL (for custom production). Each block has an Arduino circuit which includes an Arduino UNO, a speaker, a battery and connecting cables. The board system approximately costs 74 TL (no value added).

The proposed DIY system is designed to fit into the dimension of 60 x 55 x 12 cm boxes as it is shown in Figure 3.15. The kit includes platform and 9 blocks. The cost of the kit is 890 TL (no value added). Total price is calculated for a custom production, but when the serial production is the issue the price will probably be reduced.

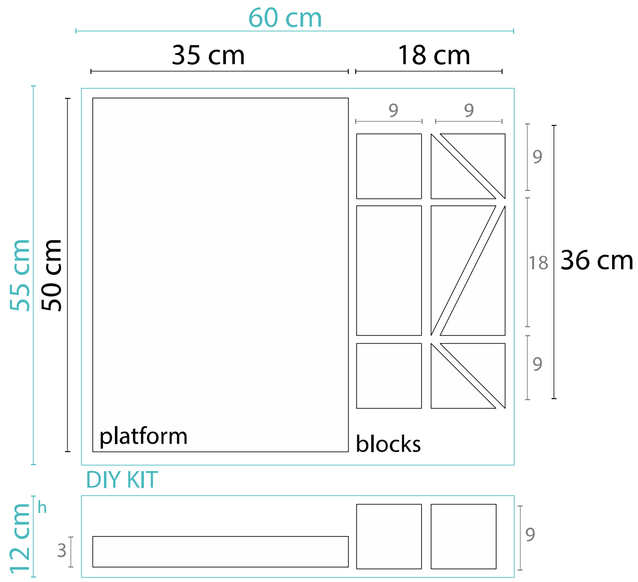


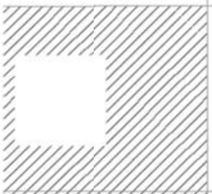
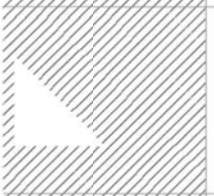
Figure 3.15 : Dimensions of the proposed kit, (by the author).

4. EXPERIMENTS WITH BLOCKS

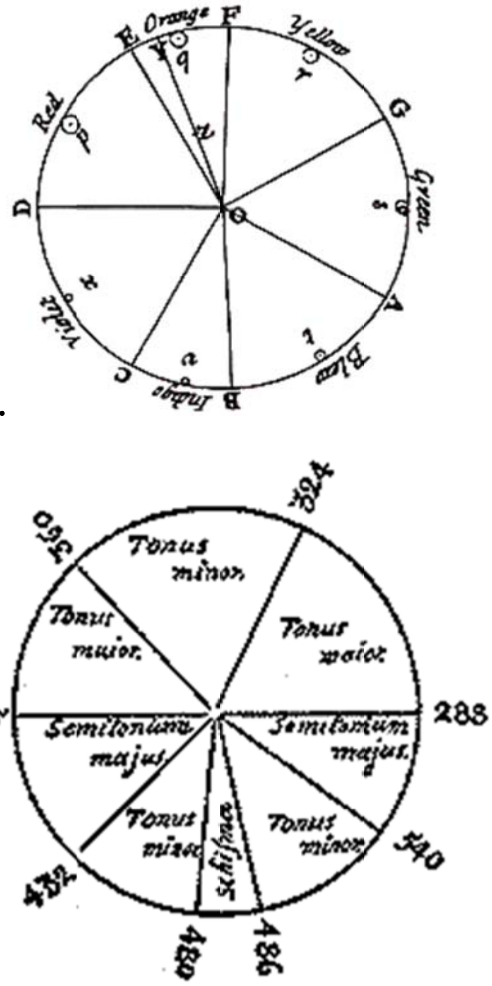
4.1 The Audial and The Visual Relationship

In Table 1.1, blocks are compared with each other with regard to their chromatic and volumetric-metric relations. Each shape corresponds with a unique musical note where is assigned to the cube as C, the small triangular prism as D, the rectangular prism as E and the other prism as F. The volumetric relationship between shapes identifies metric relations of musical notes that assigned to each block. While volume of the cube is half of the rectangular prism, the length of the sound in the rectangular prism is relatively double time long according to the volumetric size. Therefore, it provides the connection between the audial and visual quantities. For a further situation, musical notes are thought with accidental signs that change their sharpness or flatness and these notes are assigned again by taking into consideration of the volumetric relationship.

Table 1.1: Defined formal and musical relationships.

shapes	musical notation	relations: volumetric-metric relationship [duration of notes]		chromatic relationship *Newton's theory	further research: volumetric-accidental relationship [sharpness-flatness of notes]	
		volume	meter		volume	notes [flattened/sharpened]
	 [C]	2V	2/4 duple		2V	C
	 [D]	V	2/8 duple [shortest]		V	C# [half note sharper]
	 [E]	4V	2/2 duple [longest]		4V	D♭ [half note flattener]
	 [F]	2V	2/4 duple		2V	D

Newton, in his Opticks (1704) uses a circular spectrum that shows the synesthetic relation of visualization of colours regarding the tone scale. It is asserted by John Cage (1993) that Newton's circle is adapted from Descartes' diagram (1618), which is tempered diatonic octave (Evers, 2012). According to this, chromatic relationship for the blocks is specified visually equal as in shown in diagrams (Figure 4.1). Therefore, blue, red, green and yellow colors are assigned to blocks as it is shown in Table 1.1.



a.

b.

Figure 4.1 : a. The tempered diatonic octave (Compendium Musicae by Descartes), **b.** Newton’s visualization of colours.

4.2 Simulations

4.2.1 Simulation 1

According to definitions in Table 1.1, several possible processes take part to predict and understand how the setup operates. To illustrate these processes Sketch up is used as the three-dimensional modeling program. The blocks are modeled regarding their manufacturing proportions as is stated before in Table 1.1.

When the system explored by children, first the understanding of working principle of blocks, then beginning of play and examining different combinations is expected to be encountered (Figure 4.2). Creating different patterns gives the opportunity to children to enhance their visual capability and produce different harmonies of sounds together (Figure 4.3).

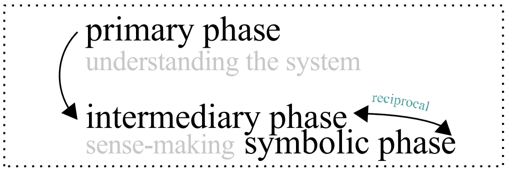


Figure 4.2 : The diagram showing expected phases of the process, (by the author).

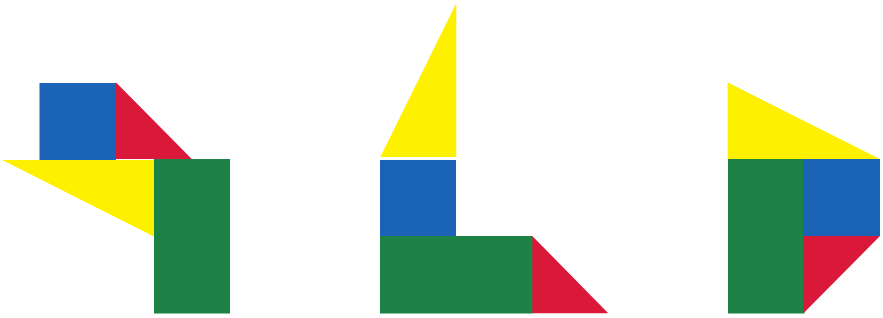


Figure 4.3 : Different pattern experiments on a flattened plane that creates different sound combinations, (by the author).

The beginning part of the play is expected to explore the system by children which is counted as the primary phase of the play. The example shows how the system basically works. Each block has a unique musical note that is previously assigned to them as it is seen in Table 1.1. By adding these blocks to the platform, the sound triggers. As children examine different combinations, they also experience dual sounds repeating during the process as it is in Figure 4.4. Therefore, children imitate their imaginary formation in a concrete way with related geometries assimilated with the sound.

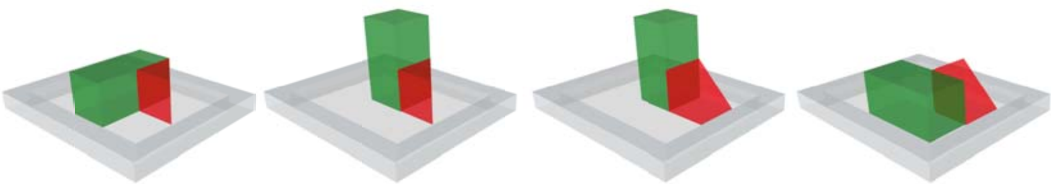


Figure 4.4 : Example of different combinations with two blocks, (by the author).

In Figure 4.5, as the intermediary phase of the activity, different movements are seen such as adding, removing or repeating. Removing is considered as pre-planned activity as in adding the block. Because removing the block also means adding one note to the stave that changes the linearity of the final sound. The children might turn that removing-adding movements into a ruled play with their own imagination.

Another main movement in the example is the repeat of adding blue cubes. Hereby, the repetition occurs in two different ways. One is adding a block to the platform and the other is touching to the block without movement. Therefore, the repetition is defined as another parameter that changes the flow of the process.

The system is not supposed to create such precise melodies as it is seen in the diagrams. The system triggers by touching and every single touch means creating sounds, which synchronously recorded by the platform. So that, to make certain combinations and in both physical and audial requires making predictions and developing strategies before each step as in chess. This is envisioned to enhance children's problem-solving skills. On the other hand, experiencing the failures is seen to enhance their encountering with error-trial methods in a didactical way as Montessori (1909) also mentions.

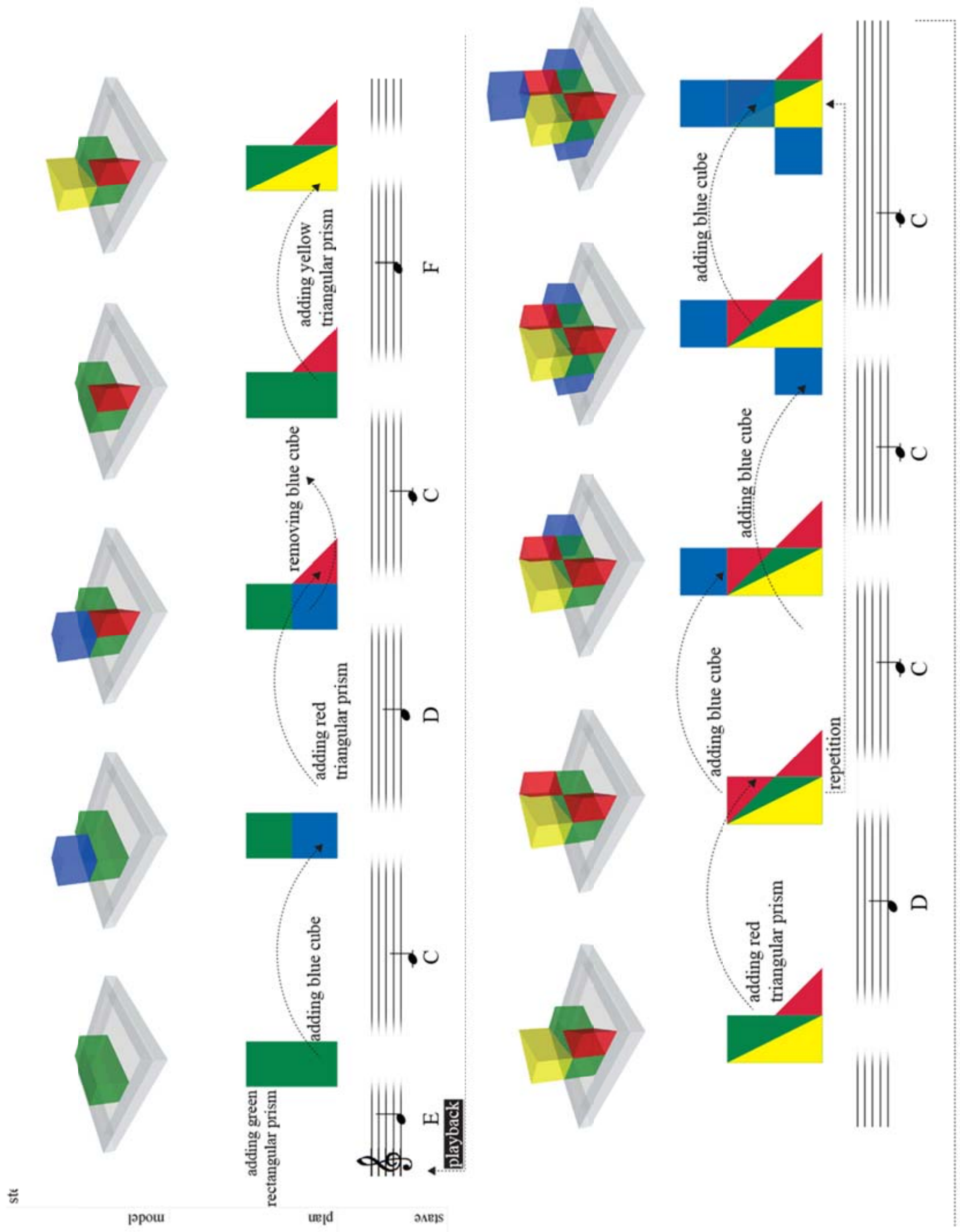


Figure 4.5 : Example of a three dimensional pattern showing adding/ removing and repeating of blocks, (by the author).

4.2.2 Simulation 2

The process of building a bird figure is illustrated in Figure 4.6. Many different orders or ways are possible to build a bird figure. In this modality, the small red triangular prisms are imagined as wings and tail of the bird. While the rectangular prism is the body, the bigger triangular prism is the head of the bird. As it is seen here, especially animal figures are expected to gain such symbolic meanings due to the synchronicity with the sound as like the sound of the singing bird.

The order of adding/removing, the coordinations and the shapes of the blocks are possible to vary according to the imagination of the children. The criteria that children define make possible to playmaking and creating their own playscape under the light of these rules.

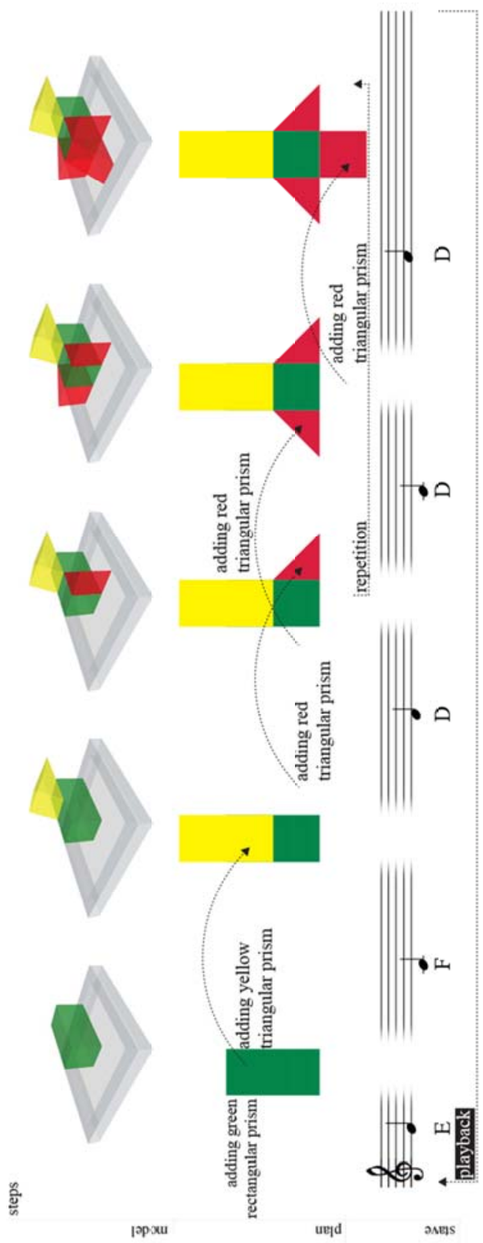


Figure 4.6 : Example of a singing bird figure referencing symbolic meaning in the play, (by the author).

For the final product, two different situations might be mentioned. Without any movements of blocks, upon the final pattern, it is possible to use blocks as three-dimensional piano just only with touching a live time process. On the other hand, recording sounds gives the opportunity to see the process and arrange the location or movements of the blocks. Therefore, each final product has a potential to act as a musical instruments.

4.3 Further Studies

The produced system with blocks is also suggestable for blind children to develop their sensorial perception. Once they feel the block from the contour of the geometries and the sound that reveals from the geometry, later blind children are able to recognize geometries from the sound. The system is possible to be acceptable as a geometric braille with the sound guidance while they can create synchronous physical combinations by hearing. Using hand gestures provides children to understand the geometric properties corresponding with the sound. By doing so, remembering the block with that sound and making the correlation between them occurs. Therefore, synesthesia that is imitated in the proposed system is considered supportive for blind children to provide the relationship between art and sensations.

5. CONCLUSIONS

The research aims to create a multi-sensorial environment that children can spatially experience tactile, visual and audial properties in the interaction. The proposed system is designed as children can easily reach the tool and adapt to the activity. At this point, blocks such as Froebel's are considered as the medium to provide the easy access to the tool. The perception of different patterns, colours and shapes visually engage children's attention to the activity and they begin to collect things to their knowledge store.

Through the research, multi-sensory integration is seen significant in order to enhance children's cognitive abilities. To create a multi-sensorial environment, the proposed system is considerd to imitate synesthesia, which means synchronously perceiving multiple senses. While they use their hand-mind coordination, the system also provides the interaction with the musical properties to develop their auditory perception and musical abilities. Using their visual and audial abilities is considered as significant from the angle of children's sensorimotor development.

During the activity, drawing up strategies and reaching the goal that they aimed is significant. However, the use of trial-error and solving problems provide to reach their goals and reveal them being individuals in their own environment. On the other hand, collaboration with other individuals is crucial to enhance their communication and prove themselves in the community. Exchange of ideas and collective movement encourages taking risks; therefore they feel ready to encounter new trials without any prejudices.

As production technology of the proposed system, DIY systems are considered which provide producing things on one's own. Reconsidering "low threshold" of Myers (2010), the lightweight of the product, manufacture as movable kits, easy to install, open source, and the low-budget, are significant for the dissemination of the use and development of the system. Therefore, different alternatives can be carried out of as the workshop areas. In a further context of the study, independent workshops are possible to be organized for children by considering possibilities of existing institutions that are planned to be in co-operation where the workshops take place in a predefined period.

In the study, public spaces, such as museums and cultural centers are considered in the context of openness and diversity in experiences. In this type of public domains, although art and technology are mostly used as combinations to enrich the experience, it is observed to be limited to superficial tools with their only informative purpose. This study is possible to be forseen as a pioneer from the angle of providing the three-dimensional synesthetic interaction with the objects.

For further researches, the system is possible to declare with other situations. In the initial years of architectural design education, several intermediary workshops are conducted to practice the design with different disciplines and make personal correlations with spatial properties. Considering my own undergraduate study at Istanbul Technical University, these workshops were generally in dualistic subjects such as music and space or dance and space. By creating such atmospheres, the space is reconsidered through music, dance, or other disciplines. Therefore, the interpretation ability is developed with other sensitivities. The research is possible to consider from this point of view as a very first step that prepares a ground for gaining a multi-sensory approach and improving children's spatial recognition. On the other hand, using hand-mind correlation is possible to improve learning abilities by children's hand gestures. Further, this may lead improving their visual-spatial ability and making interpretations in physical modelling in the beginning phase of the design in architectural education.

REFERENCES

Ackermann, E. K. (1993). Tools for Constructive Learning: Rethinking Interactivity. Massachusetts Institute of Technology. Epistemology & Learning Research Group

Ackermann, E. K. (2004). Constructing Knowledge and Transforming The World. *A learning zone of one's own: Sharing representations flow in collaborative learning environments.* Part 1, Chapt 2., pp. 15-37.

Cytowic, R. (2002). Synesthesia: A Union of Senses. The MIT Press, Cambridge, Masachusetts.

Descartes, R., (1650). Musicae Compendium. Strassbourg: P.-H. Heitz.

Evers, F. (2012). The Academy of the Senses: Synesthetics in Science, Art, and Education. Edited by Vincent W.J. van Gerven Oei. The Hague ArtScience Press.

Fass, P. (2004). Encyclopedia of Children and Childhood in History and Society. Vol I-II-III, Macmillan Reference USA.

Gibson, J. (1962). Observations on Active Touch. Psychological Review, Vol 69 (6), November.

Ione, A., Tyler, C., (2003). Neurohistory and the Arts. Was Kandinsky a Synesthete?, Journal of the History of the Neurosciences, Vol. 12, No. 2, pp. 234-226.

Kay, I., Karakaş, H., Özkar, M., (2015). From Bodies and Objects to Silhouettes: Mediating Active and DIY Playscapes. Places for Learning Spaces Symposium 2015, Thessaloniki, Greece.

Montessori, M. (1909). The Montessori Method. Edited by Gerald Lee Gutek. Rowman & Littlefield Publishers, Published in the United States of America, 2004.

Neumann, M. M., Neumann, D. L., (1909). Touch Screen Tablets an Emergent Literacy. Early Childhood Educational Journal, July 2014, Volume 42, Issue 4, pp 231-239.

Newton, I., (1704). Opticks or A Treatise of the Refractions, Inflections & Colours of Light. New York: Dover.

Mugellini, E., **Rubegni, E., Gerardi, S., Khaled, A. O.,** (2007). Using Personal Objects as Tangible Interfaces for Memory Recollection and Sharing. In proceedings of TEI '07, pp. 231-238.

Myers, A. B., Hudson, S. E., Pausch, R. (2010). "Past, Present and Future of User Interface Software Tools," ACM Transactions on Computer Human Interaction. March, 2000. 7(1). pp. 3-28.

Papert, S., (1993). Mindstorms: Children, Computers, And Powerful Ideas, Basic Books. New Ed edition, July 14, 1993.

Plato, (n.d). Laws.

Resnick, B., M., Nakakoji, M., K., Shneiderman, B., Pausch, R., Selker, T., (2005). Design Priciples for Tools to Support Creative ThinkingNSF Workshop Report on Creativity Support Tools, Revised October 30, 2005.

Singh, T. (2009). Capacitive Sensor Interface Circuits. Norwegian University of Science and Technology. Phd thesis, July.

Wenger, E., (2002). Communities of Practice Learning, Meaning and Identity, Cambridge University Press, United Kingdom.

Url-1 <*http://www.religio.de/froebel/gifs/froe1.gif*>, date-retrieved 25.03.2015.

Url-2 <*http://www.froebelblocks.com/images/froebel_gift_6.jpg* >, date-retrieved 25.03.2015.

Url-3 <*http://innovativelearningcentre.ca/wp-content/uploads/2014/09/littleBits1.jpg* >, date-retrieved 12.04.2015.

Url-4 <*http://blog.arduino.cc/wp-content/uploads/2013/11/Primo_programming.jpg*>, date-retrieved 12.04.2015.

Url-5 <*http://makeymakey.com/*>, date-retrieved 12.04.2015.

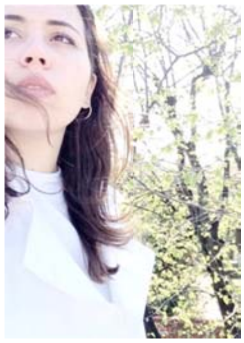
Url-6 <*http://www.icare4autism.org/wp-content/uploads/2012/04/MP900430890.jpg* >, date retrieved 03.04.2015.

Url-7 <*http://kykolnik.livejournal.com/525274.html?thread=5131482*>, date-retrieved 05.04.2015.

Url-8 <*http://www.thebubble.org.uk/art-photography/kandinsky-synaesthesia-and-the-spiritual/*>, date-retrieved 12.04.2015.

Url-9 <*http://www.arduino.cc/en/uploads/Main/ArduinoUno_R3_Front.jpg*>, date-retrieved 16.04.2015.

CURRICULUM VITAE



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'12- '13 Fulbright Scholarship Candidate

Dean's High Honor List; 2009 & 2010 Spring Semester, 2010 Autumn Semester
Dean's Honor List 2007 & 2008 Autumn Semester

Sisli High School Competition [August '11] [Taken honourable mention [as a team member of Superpool & Kerem Piker]

All Design '11 'Future by Design' [October '11] Taken 2nd honourable mention

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