CHILDREN’S EXPECTATIONS FROM LEARNING TECHNOLOGIES

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ABSTRACT

CHILDREN'S EXPECTATIONS FROM LEARNING TECHNOLOGIES

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The aim of the thesis is to find out children's expectations from smart products that enhance their learning and analyze their conformity with the state of art smart products and educational technologies. The developments in technology affect many dimensions including education. There are many studies that aimed to improve the learning process by the help of technology. However, the perspective of children considering this topic is almost absent in the literature. Therefore, expectations of children from learning technologies are explored via an empirical study. The state of art smart technologies and products to enhance learning will also be covered. Then, in the light of an empirical study, to what extent children's expectations overlap with current technologies will be presented.

Keywords: Learning Technologies, Children's Expectations, Smart Products

ÖZ

ÇOCUKLARIN ÖĞRENİM TEKNOLOJİLERİNDEN BEKLENTİLERİ

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Bu tezin amacı, çocukların öğrenmelerini geliştirecek akıllı ürünlerden beklentilerini bulmak ve söz konusu beklentilerin şu an varolan akıllı ürün ve öğrenim teknolojileri özellikleriyle ne kadar örtüştüğünü incelemektir. Teknolojik gelişmeler eğitim de dahil olmak üzere bir çok alanı etkilemiştir. Öğrenme sürecini teknoloji yardımıyla geliştirmeyi amaçlayan birçok çalışma yapılmıştır. Ancak, literatürde çocukların bu konu ile ilgili bakış açılarını değerlendiren çalışma neredeyse yoktur. Bu sebeple, çocukların öğrenim teknolojilerinden beklentileri ampirik bir çalışma ile araştırılmıştır. Literatür araştırması kısmında, akıllı teknolojilerin ve öğrenme sürecini geliştiren araçların geldiği son durum ortaya konulmuştur. Ampirik çalışma ile elde edilen sonuçlar ışığında bu akıllı ürünlerin ve eğitsel araçların, çocukların beklentilerini ne ölçüde karşıladıkları tartışılmıştır.

Anahtar Kelimeler: Öğrenim Teknolojileri, Çocukların Beklentileri, Akıllı Ürünler

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TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

CHAPTER 1

INTRODUCTION

1.1 PROBLEM DEFINITION

Technology advances exponentially. As the electro-mechanical components of the products become smaller, the products become handle-held sizes and as the wireless network become more widespread, products become more connected. Each day more complex and pervasive technologies get into our daily lives. The peak point that the technology has been reached is smart products which are capable to sense-act and perform many tasks with or without user interference.

Many fields are affected from technological developments and utilize its benefits. Field of education is among them. Educational sciences take the advantage of technology since the very beginning. Today, computers and Internet are indispensable components of education. More advanced technologies such as interactive tools, mobile devices and smart environments have already begun to be implemented into education.

There are an abundant number of studies aimed to enhance learning with the use of technology. Majority of those studies are conducted either to implement latest technology to education to assess the efficiency or to blend educational theories with already used technologies and analyze how the learning process affected. Nevertheless, there are few studies that are focused of the perspective of the learners, and almost none for young learners.

In design profession it is very important to be aware of the needs and expectations of the user group to design successful products. User-centered design methods are utilized to discover user needs and expectations. While designers adopt user-centered design to ensure successful usage experience, educators adopt learner-centered view to provide successful learning experience. Both views in two different disciplines set forth the importance of being aware of the perspective of the focus group. This is even more important when designing for children since their mental models are different from adults.

Children today, live in a world of information, communication technologies both in their homes and schools. Most of them already become technology-literate when they start to school. Those children who grow up in the World Wide Web era are called *Generation Y* or *Net Generation* and they have different understandings, knowledge and routines then previous generations (Oblinger & Oblinger, 2005). Prensky (2001) coined the term “digital natives” for those children, claiming that they think and process information differently from “digital immigrants” who are today’s adults that grew up in the absence of technology. The user group of learning products is very different from the designers who belong to previous generation. Therefore it is very hard for both designers to design and educators to decide for children without including them into process.

Consequently, there is an obvious need for giving voice to children to understand their needs and expectations in order to lead the designers to design better learning technologies.

1.2 AIM OF THE STUDY

The aim of this study is to discover the children’s expectations from learning technologies and to reveal to what extent these expectations intersect with technological trends and educational technologies. Such concerns as designing a learning technology or building design guidelines for designing educational tools are beyond the scope of this study. The main research question is; what are the expectations of children from learning technologies and to what extent those expectations overlap with current technological trends and learning technologies?

1.3 STRUCTURE OF THE THESIS

The thesis is structured into four chapters following the introduction. The focus of each chapter is illustrated in Table 1-1.

Chapter 2 gives an overview about state-of-art smart products under three main sections; smartness properties, physical properties and interaction. The features that make a product smart are described in first section. Ubiquitous computing view is presented along with other physical properties of the smart technologies in second section. Smart objects, smart environments, smart systems and their features are also covered. Last section deals with interaction styles of smart products, mainly focusing on natural interactions.

Table 1-1 Structure of the thesis and research questions

Chapter	Research Questions
2 - State-of-art Smart Products	What are the features of smart technologies? • What are the smartness features? • What are the physical properties of smart products? • What interaction styles do the smart products embody?
3 - State-of-art Learning technologies	What are the features of technologies that are designed for education? • What are the learning methodologies that utilize technology? • How does technology change learning?
4 - Children's Expectations from Learning Technologies	What are the children's expectations form learning technology? • What are the expected smartness properties? • What are the expected physical properties? • What are the expected interaction styles?
5 - Conclusion	To what extent expected properties overlap with current technological trends and learning technology?

Chapter 3 focuses on state-of-art learning technologies; methodologies and products. Electronic learning, mobile learning and ubiquitous learning are described as methodologies that benefit from technology. How learning changed with technology and the features of new learning technologies are examined. Lastly, prominent examples of learning environments and products and their features are covered.

Chapter 4 opens with a brief description of design methods with/for children. Then, an empirical study is presented which aims to discover the children's expectations from smart technologies that enhance their learning. The findings of the study reveal the expected properties of learning technologies from children's perspective.

In the final chapter the findings of literature survey and empirical study is compared to reveal to what degree current smart products and learning technologies corresponds the expectations of children.

CHAPTER 2

STATE-OF-ART SMART PRODUCTS

2.1 INTRODUCTION

Due to the continuing miniaturization of computer chips and electro-mechanical devices and spread of Internet and wireless connectivity, technologies are getting smarter as their computing power and communicating skills increase. As the main components of those products (such as microcontrollers, microprocessors, data storage units and sensors) get cheaper, smart technologies are become embedded into every kind of consumer product. They are in our lives for more than a decade, blended in our daily lives, as automatically opening doors, digital personal assistants, smart phones, car navigation systems, smart classrooms etc.

There are many research areas in literature evaluating smart technologies from different aspects. Although in some studies those technologies go by other names such as *intelligent*, *ambient intelligence*, *aware*, *active*, *interactive*, *reactive*, *proactive*, *adaptive*, *assistive, automated*, *autonomic*, *sentient*, *thinking etc.* all of them refer to an object/system/environment that inhabits smartness to an extent. What it is meant by the term “smartness” will be discussed and illustrated with sample products in the following section while subsequent sections will cover state-of-art smart products in terms of physical properties and interaction.

2.2 SMARTNESS

There are many different definitions for smartness in the field from broad to specific. The degree of smartness also differs in definitions, for some researchers an embed microprocessor is enough to call that product “smart” while some others detailed the definition in accordance with their focus on the study.

Although it is widely adopted by researchers, the term “smart” is hard to define within a simple sentence. Thus, it is better to focus on the mentioned characteristics in literature.

For example, the researchers in the Smart Product Design Laboratory in the Stanford University describe smart products as products whose functionality is increased by an embedded microprocessor which can already be found in everything from dishwashers to automobiles ("The Smart Product Design Lab," 2011). This is a broad perspective for other researchers who are especially in ubiquitous/pervasive computing field. Such as Cook and Das (2005) who defined smartness as the ability to autonomously acquire and apply knowledge, adapt to its users in order to improve their experiences.

In the following studies, smartness characteristics are further detailed. Ma et al. (2005) pointed out that smartness is not only being able to sense, think and act (actions/reactions/proactions), but also communicate with other technologies and interact with people. Rijsdijk et al. (2007) explicated six key dimensions of smartness; *autonomy*, *ability to learn*, *reactivity*, *ability to cooperate*, *humanlike interaction*, and *personality*. In *personality* dimension, the smart product shows a credible character and in *humanlike interaction* smart products understand and produce speech. The two dimensions contribute and elaborate interaction between smart products and its users. In their latter study, Rijsdijk and Hultink (2009) added another dimension to smartness characteristic; multifunctionality which refers to a single product has the ability to serve multiple purposes. Maas and Janzen (2007) also constituted six dimensions of smart products; *Situatedness, personalization, adaptiveness, pro-activity, business awareness* and *network capabilities*. Smart products are expected to *proactively* predict possible actions and they should be *business aware* which refers to awareness of business and legal constraints.

Hebner (2009) wraps up the qualities of existing smart products as follows;

> When software is effectively fused with microelectronic, actuator, sensor and mechanical technologies, products can become increasingly interconnected, intelligent and instrumented. That is, they can respond to changes quickly and accurately and produce better results by anticipating and optimizing for future events. They can measure and sense the relevant conditions and are able to interact with other products, people and IT systems in entirely new ways. This is what makes them “smart”—their ability to adapt to the unique needs of individual businesses and people (p.9).

Figure 2-1 illustrates a summation of smartness characteristics that are found in the literature.

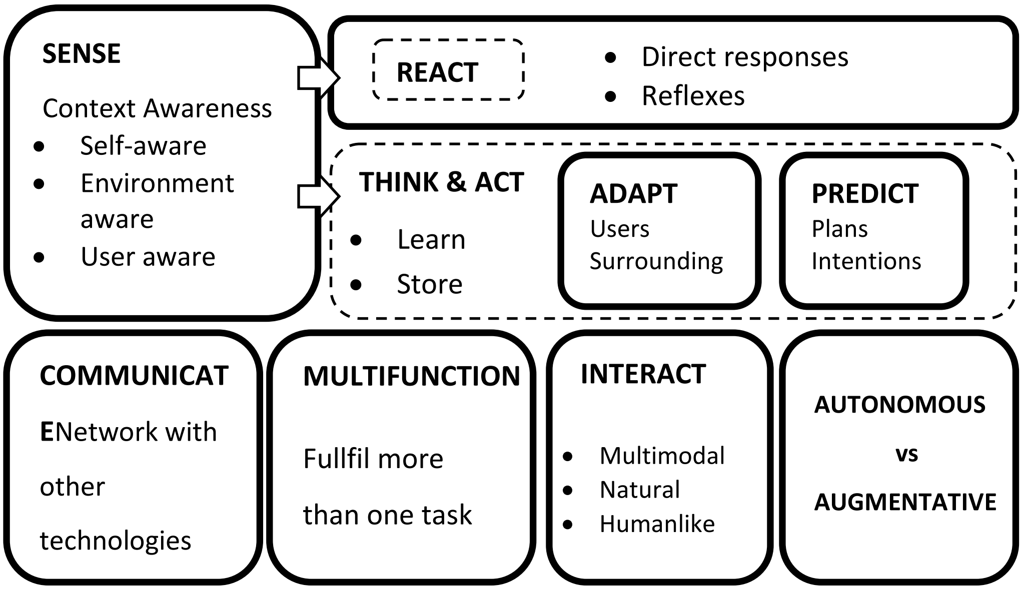


Figure 2-1 Smartness Characteristics

In the literature, there are many studies which adopt these smartness characteristics to a lesser or higher degree, depending on the focus of their study (Kelly, Daly, & O'Driscoll, 2009; Kortuem, Kawsar, Sundramoorthy, & Fitton, 2010; Lyardet & Aitenbichler, 2008). Also there are a lot of existing physical or digital smart products that have properties matching one or more of these characteristics. Autonomy is not directly counted among smartness characteristics because it’s a controversial issue, since some of the researchers think that smart products should be augmentative rather than autonomous. Following sections will scrutinize on the characteristics of smart products.

2.2.1 Sensing

In order to process and act accordingly, smart technologies need to obtain information about its users, environment or self. Thus, smart products need to be “aware” of context it is in. A context-aware object/environment can discover and take the advantage of contextual information such as user location, time of day, nearby people and devices and user activity (G. Chen & Kotz, 2000). The term “context” basically covers four main elements (G. Chen & Kotz, 2000; O'Driscoll, Mohan, Mtezi, & Wu, 2008)

- *Computing context, made up of nearby computing resources, communications and communications bandwidth.*
- *User context, such as the user’s profile, location, people nearby and even the social situation.*
- *Physical context, such as lighting noise levels, traffic conditions and temperature.*
- *Time context, where user and physical contexts can be logged to provide a context history that can be useful in certain applications.*

For context acquisition smart products rely of various types of sensors. The types of sensing technologies are shown in the Table 2-1, which is adapted from the classification mentioned in the study of Schmindt (2002).

Table 2-1 Sensing technologies and acquired data

Sensing Technologies	Sensors	Acquired Data
Light and Vision	Cameras Optical sensors (IR, UV, photo-diode, color)	• Detection of objects, landmarks, people, gestures etc. • Visual information about environment (light intensity, color, motion etc.)
Audio	Microphones Amplifiers	• Noise, music identification • Speech recognition
Movement and Acceleration	Mobile, wearable artifacts Accelerometers Gyroscopes	• Detection of body movement, gestures • Detection of directional and angular acceleration

Table 2-1 (cont'd)

Location and Position	GPS and dGPS GSM Cellular network RFID tags and readers	• Location information • Detection of position of the device
Magnetic Field and Orientation	Electronic compass	• Detection of geographical directions
Proximity, Touch and User Interaction	Proximity sensors Humidity sensors Conductive surfaces Force sensitive resistors Light and temperature sensors Cameras	• Detection of proximity of the user • Detection of touch/grip • Detection of user's emotional state • Detection of body movement and gestures
Temperature	Temperature sensors Passive infrared sensors	• Detection of the physical conditions of the environment (temperature) • Detection of heat flow (moving heat sources; users)
Humidity	Humidity sensors	• Measuring of the weather conditions • Detection of human existence
Air Pressure	Air pressure sensors	• Detection of opening and closing doors
Weight	Weight sensitive surfaces	• Detection of movement and position • Detection of specific user
Gas-Sensors and Electronic Noses	Gas sensors Specific smell sensors	• Detection of gas concentration in air • Detection of alcohol/food
Bio-Sensors	Heart rate sensors Skin resistance sensors Electrodes	• Emotional state/health condition of the user • Detection of affective inputs (excitement, tension)

Sensor technologies allow smart products to acquire knowledge about its environment, its users and the way it interacts with users (the interaction between users and smart products will be further elaborated in upcoming section). Collected knowledge then either valued in the learning process to adapt user preferences and environment or smart product directly reacts accordingly.

2.2.2 Reacting

Reactive products have the ability to directly respond to changes in their environment acquired by sensors. Comparing to adaptive systems, reactive ones have simple intelligence, which basically function like reflexes in a stimulus/response manner (Bradshaw, 1997). Reactive smart products are closely tied to their perception of their environment, because the sensory input is the only source of information. Contrary to *learning* process, no internal models of surroundings are needed for these reactions; product just observes something and takes action on the basis of that observation (Rijsdijk et al., 2007). Examples of reactive products are fire alarms that depend on heat and smoke detectors, and react to changes in sensory input via triggering alarm system, sprinkler or informing fire station.

Smart materials may also be included in reactive products. Instead of detectors and micro-controllers, molecular structures of smart materials react upon the changes in environment. Smart materials have diverse usage areas from health to engineering. They respond to changes in light (photo-chromic materials), temperature (thermo-chromic materials), and mechanical stress (piezoelectric) etc. Changes in their appearance inform users about the changes in the environment, in a way they communicate the changes.

For example, the Coral thermo-chromic pot designed by William Spiga and Juliana Martins, inform users about the temperature of the pot (Figure 2-2). If the pot gets hotter, the outer frame is covered with red spots, warning users not to touch with bare hands.

Figure 2-2 Thermo-chromic pot (Retrieved from www.yankodesign.com)

2.2.3 Think & Act

Unlike the reactive smart products, some products act deliberately. Deliberative smart products collect and store information about their environment, and they build an internal model that represents the environment and this internal model is used to perform complex decision making tasks (Nwana & Ndumu, 1997) such as predictive and adaptive behaviors. Rijsdijk and his colleagues emphasized the learning as follows;

> The ability to **learn** refers to the ability of a product to **store** information and consequently **adapt** to its environment (e.g., its user or the room in which it is placed) over time, which may result in better performance. Products that can learn are generally programmed with algorithms that use data that is collected over time, and influence the manner in which a product operates. The ultimate product intelligence is learning from experience (Rijsdijk et al., 2007, p.342).

According to Heierman et al. (2002) learning framework is the backbone of intelligent systems and three different learning approaches can be utilized;

- *Rote training*; user decides the exact system behavior. For example, the user may set the alarm to 8:00 AM and turn the coffeepot on through the system.
- S*upervised approach*; user provides training examples, which are generalized by the system to predict future behavior. A mechanism is required that allows the user to indicate when supervised training is taking place.
- *Observation approach*/U*nsupervised learning;* system passively observes behavior and learns appropriate activities. It doesn't require direct interaction. A system using learning by observation is clearly the least intrusive.

Rashidi et al. (2007) believe that smart systems can be guided by "rewards" (positive feedback) for desired behaviors and negative feedback for undesired behaviors. For example, if the user turns a light back on which was turned off by the smart environment in order to save power, this provides negative reinforcement for the learner.

Those learning mechanisms are the backbone of the adaptive and predictive smart products that rely on various types of algorithms to decide.

2.2.3.1 Adaptive & Predictive smart products

Smart technologies should be adaptive since the world is a dynamic place; environments evolve as the devices and users change, a smart system must evolve with the environment (Heierman et al., 2002). Adaptive smart products are able to improve the match between its functioning and its environment (Nicoll, 1999), they change according to users, tasks and environment in a particular situation. For example, in the case of adaptation to environment; a smart PDA may dim the screen brightness when it realizes that product is used in a dark environment. Yet, if the user increases the screen brightness, right after the smart products adaptive behavior, product also changes its behavior for the next time, predicting that user prefers increased screen brightness even in a dark environment.

Contexts of users and environment can be predicted based on the models that are built according to users' activity patterns which in turn can be used for anticipating future user needs and preferences (Das & Cook, 2005). For example, a smart car may collect information about the user preferences by observing the patters of routes (work, school, restaurant, gas station etc.), the time of the trip and combine this information with the data gathered from the internet and can make warnings about in which route the traffic is jammed, and give suggestions about non-congested routes based on the learned model of activity patterns.

In his study, Mozer (2005) gives a good example of adaptive and predictive system properties via *adaptive house* scenario. On weekdays, inhabitant leaves the house at 8 a.m., and on the previous 3 days he returned 7 p.m., so the adaptive home predicts a return by 6:30 and runs the furnace to achieve preferred temperature by that time. On the weekend days, when the inhabitant leaves the home at 4 p.m., his return is not anticipated until past midnight and the house is not heated before then. When the inhabitant returned at the anticipated hour (1 a.m.), the prediction is made that only the bedroom will be used for the next 7 hours, therefore the rest of the home isn't heated. If the inhabitant awakens at 4 a.m., home predicts that he intended to use the bathroom, and the bathroom light is turned on before the user reaches.

Smart products acquire data about its users and environment through sensors and direct user interaction and learn through observation, supervised learning and rote training. Consequently, smart products form internal models of environment and user activity patterns which allow them to adapt to users/surroundings and predict needs, preferences, plans and intentions. Figure 2-3 illustrates the learning process.

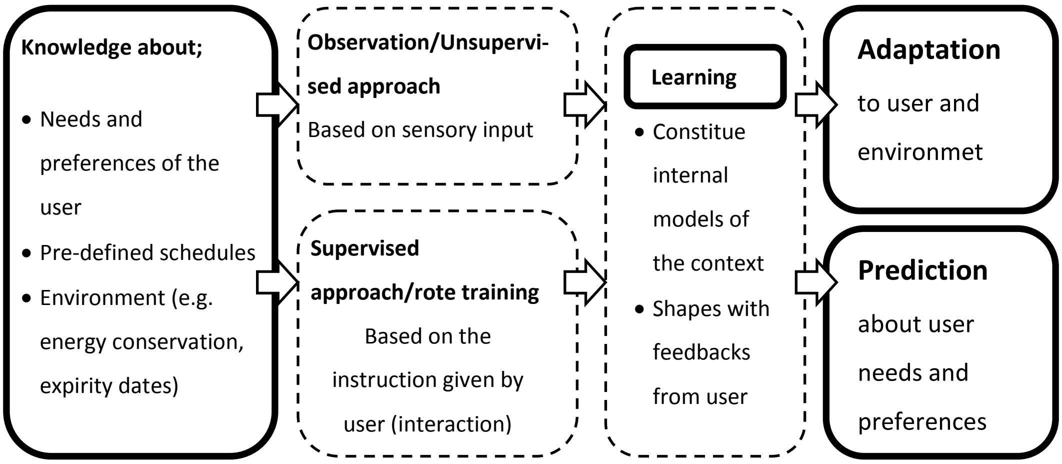


Figure 2-3 Learning process in smart products

2.2.4 Communicate

Being connected and be able to communicate with other technologies are essential properties of smart products. Smart products should be compatible with other technologies to achieve diverse tasks. For example, a digital camera has to be compatible with printer and computer to function properly. Today smart products can communicate with each other via local or global networks and Internet. Besides, mobile smart technologies made the both wire and wireless network access a necessity in order to provide anywhere/anytime connection (Heierman et al., 2002).

In terms of smart environments such as smart homes, whole operation of the system depends on connectivity. The basic intention of the smart environments is to control and manage all of its various networked devices, such as cameras, sensors, computer and appliances, from anywhere and at any time through the Internet (Das & Cook, 2005). The connectivity in a smart home context is shown in Figure 2-4.

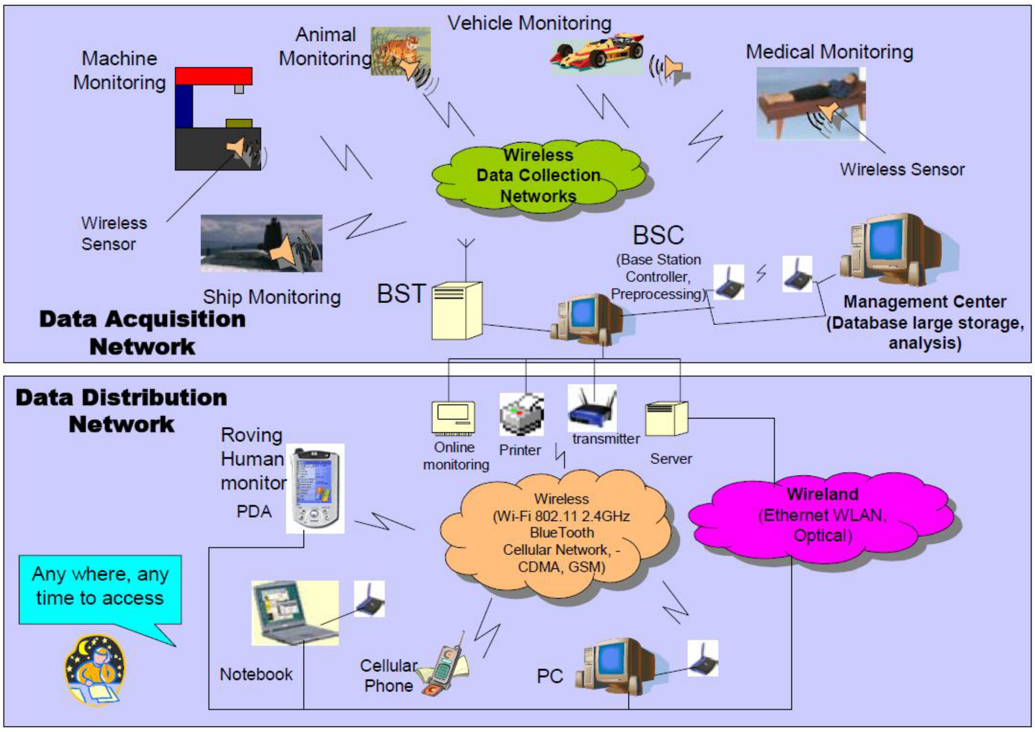


Figure 2-4 Connectivity in a smart home (Retrieved from Lewis, 2005)

Ma et al. (2005) envisions the future of connected smart products will be to first interconnect some associated smart spaces together to form a smart hyperspace, and then integrate all the smart spaces/hyperspaces together with the cyberworld, to finally create the smart world. Thus, connection among the smart products especially through Internet will become even more important in the future.

2.2.5 Multifunction

As the technology enhances, simple products become embodied with multiple functions and as mentioned at the beginning of the section, *multifunctionality* is one of the smartness dimensions. Historically, when the computers first emerged, multiple numbers of people were using one computer, in time technologies became more accessible and user began to posses many digital products. Now the contemporary products commonly embody multiple futures (Figure 2-5). A very prominent example is cellular phones and tablet PCs. The cellular phones used to allow user just to communicate with each other, then various functions integrated to them; camera, music player, Internet browsing and even GPS systems.

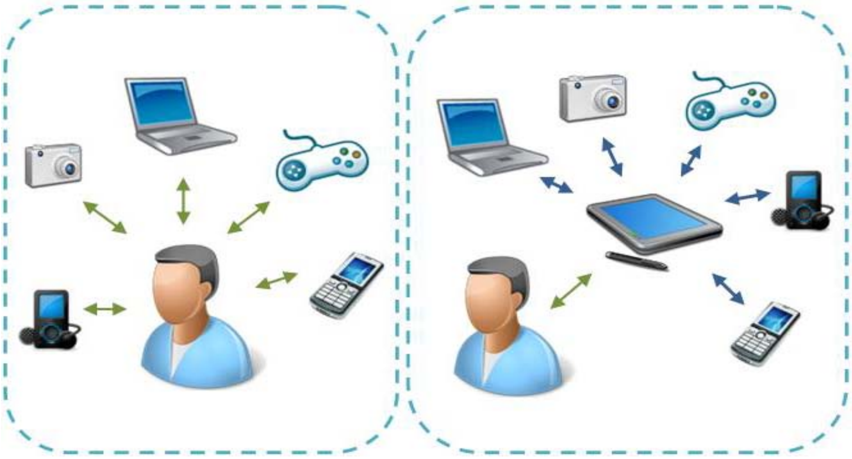


Figure 2-5 Contemporary multifunctional products embody various features.

However, it is risky to embed many functions to a simple product. Rijsdijk and Hultink (2009) found that higher levels of *multifunctionality* increase the complexity and the risk that users perceive, so the benefits of adding multiple functions to a product are limited. Therefore, they suggest introducing products in the market place only with a moderate increase in multifunctionality.

2.2.6 Autonomous vs. Augmentative

Autonomy refers to the ability to operate independently without any intervention from users. The researchers especially in ubiquitous/pervasive computing field are strong proponents of autonomy in smart systems. According to Poslad (2009), autonomy is one of the core property of ubiquitous systems; he believes that without autonomous systems, a number of various tasks in an advanced technological society that require human interaction would overwhelm users and make system operation unmanageable. Heierman and his colleagues see autonomy as a key characteristic of smart environments and describe their goal as follows;

> The goal of any intelligent environment is to automate the usage of the devices within the environment. The system automatically turns devices on and off, directs information to the appropriate devices, and simplifies the coordination of multiple devices. Environment automation allows an inhabitant to concentrate on the task at hand, rather than on the devices necessary to perform the task. It is important not to confuse centralized device control with environment automation. We do not consider an environment that only

> provides device control to be an intelligent environment. Automation is the key characteristic of an intelligent environment (Heierman et al., 2002, p.2).

Norman (2007) points out that automated systems may be dangerous if they fail to detect a problem or act when it shouldn't have. For example, if a smart car incorrectly decides to stop or slow down, it may cause a serious accident or a fire detector which triggers false alarm several times may cause inhabitants to ignore it in a real fire.

Autonomous systems may also obligate the user to follow its decisions. The products embedded autonomous intelligent might be programmed to adhere to a build-in set of rules that its owner didn't set and doesn't want to follow (Cronin, 2010). For example, a smart product may not be compatible with other technologies except a specific brand or even autonomously orders its consumables from internet without consulting to its user. Therefore, a small amount of user intervention may help to overcome difficulties and provide more pleasing experience in these kind of systems (Brotherton & Abowd, 1998).

Taylor et al. (2007) designed a smart home without sensors and infrastructures, claiming that the home is already smart with the practices of inhabitants (such as the family communication practice via fridge magnets) and utilize products only to assist the inhabitants. What they emphasis is to augment human intervention with technology rather than automate all the practices. Augmentative smart products assist users, give suggestions and leave the decisions to them, rather than deciding for them.

Norman (2007) asserts that smart products should be augmentative rather than autonomous and envisions that future smart products will be augmentative;

> The future of design clearly lies in the development of smart devices that drive cars for us, make our meals, monitor our health, clean our floors, and tell us what to eat and when to exercise. Despite the vast differences between people and machines, if the task can be well specified, if the environmental conditions are reasonably well controlled, and if the machines and people can limit their interactions to the bare minimum, then the intelligent, autonomous systems are valuable. The challenge is to add intelligent devices to our lives in a way that

supports our activities, complements our skills and adds to our pleasure, convenience, and accomplishments, but not to our stress (p.134).

2.3 PHYSICAL PROPERTIES

2.3.1 Ubiquitous and Pervasive computing vision

Wieser and Brown back in 1997 indentified three computing eras (shown in the Table 2-2). It is called mainframe computing when the computers were newly emerged, many users were using a single computer. Later as the computers became cheaper and more accessible; the era of personal computer has begun. According to the researchers, at the time they published their work (1997), the world was living a transition era; internet-widespread distributed era. Finally, upcoming era is foreseen as ***ubiquitous computing*** in which there will be multiple numbers of computers for each user.

Table 2-2 Three eras of computing (Retrieved from Weiser & Brown, 1997)

The Major Trends in Computing	
Mainframe	many people share a computer
Personal Computer	one computer, one person
Internet - Widespread Distributed Computing	*. . . transition to . . .*
Ubiquitous Computing	many computers share each of us

Wieser (1991), pioneer researcher of ubiquitous computing, envisioned the future as a world in which a sheer number and variety of computers with different functions will be everywhere, ubiquitously embedded in every kind of object. For some groups of people ubiquitous computing is already here with applications and technologies such as mobile phones, e-mail and messaging systems (Poslad, 2009).

Ubiquitous computing is later called pervasive computing by IBM researchers. Saha and Mukherjee (2003), asserts that pervasive computing evolved from distributed and mobile computing (Figure 2-6). Distributed computing was the next step of personal computing, because personal computers was connected via network, allowing users to access remote information resources (Satyanarayanan, 2001). Mobile computing flourished when the mobile technologies integrated with Internet. While the ultimate aim of the mobile computing was to provide *anytime anywhere connectivity*, pervasive computing vision extent this aim to a*ll the time, everywhere* (Saha & Mukherjee, 2003).

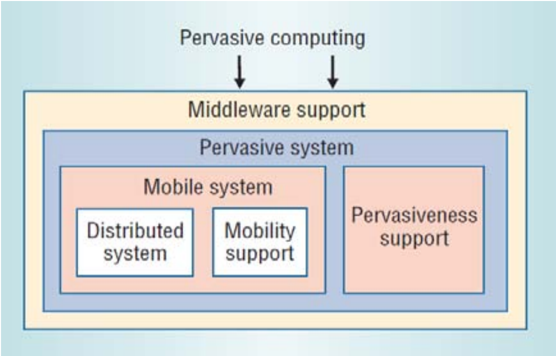


Figure 2-6 Pervasive computing comprises distributed and mobile computing (Retrieved from Saha & Mukherjee, 2003).

The vision of ubiquitous computing became academic research agenda and influenced designers in innovative commercial sector. In 1999, Philips Design defined their design philosophy; “the home of the future will look more like the home of the past than the home of the present. It will be less cluttered, with objects that blend smoothly into our lives. Televisions will be part of the walls, stereos disappear into bookcases” (Marzano, 1999).

The idea of Wieser and his followers is that *in the future the computers will be seamlessly and non-intrusively embedded in physical environment and invisible to users* also became a subject of a caricature in a blog named Harold’s Planet (Figure 2-7).

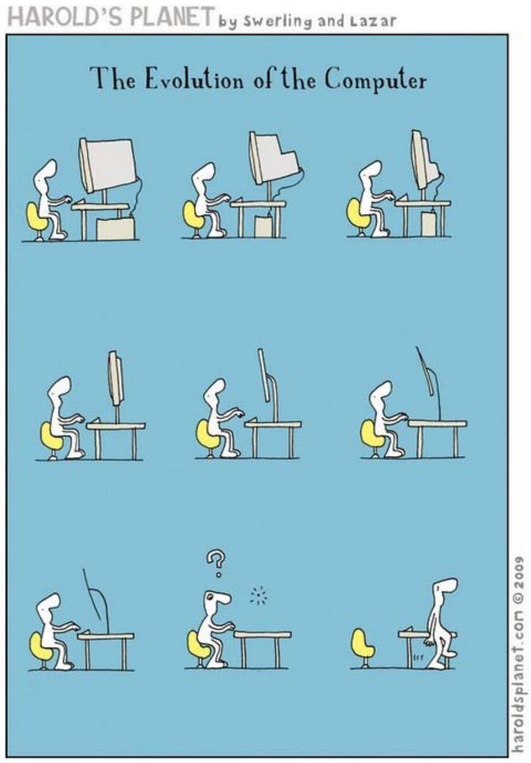


Figure 2-7 The evolution of computer (Retrieved from harolds-planet.blogspot.com)

2.3.2 Smart ubiquitous things

In contrast to cyber world in which there are virtual representations of the real physical things (such as e-classroom, e-money etc.), ubiquitous world enhances physical objects with technology. Ma (2005) called those physical ubiquitous objects *as u-things* and divided them into three categories; smart objects, smart spaces and smart systems.

2.3.2.1 Smart objects

Today it is easy to see ***sophisticated smart objects*** around, such as smart TVs, smart phones, tablets etc. For example, cameras perform task that users used to perform; sensing the distance, light and adjusting focus and ISO autonomously. Moreover, they have other functions such as capturing video just like a camcorder, and sharing it online. There are many multifunctional complex smart objects around, and they will unstoppably continue to be introduced to the market.

On the other hand, ubiquitous computing vision embrace the fact that most profound technologies are those that disappear into everyday objects (Wieser, 1991). Everyday objects can be anything; keys, pens, watches, tables, cloths etc.

Many researchers and designers who follow ubiquitous computing vision, already started to design and implement such ***smart everyday objects***. For example, designers of Ambient Devices Inc. presented the *Ambient Umbrella* which allows its users to know when rain or snow is in the forecast by illuminating its handle ("Ambient Umbrella," 2011). A simple everyday object, umbrella, turns into a smart object that warns via light patterns (indicating rain, drizzle, snow, or thunderstorms) with the help of data gathered from Internet. More or less same weather forecasting technology embedded in clocks, tablets and even smart refrigerators (Figure 2-8).

Figure 2-8 Ambient Umbrella and Smart refrigerator (Retrieved from www.ambientdevices.com, www.myambient.com respectively)

Moreover, advanced connectivity allows more and more smart objects to enter our daily lives. Apple and Nike shoes collaborated for a smart design to monitor personal training (Figure 2-9).

Figure 2-9 Sensor embedded shoe communicates with smart media to monitor training (Retrieved from www.apple.com).

A sensor is placed in left shoe (in the built-in pocket beneath the insole), allows users to monitor their workout via voice-feedback while they are listening music in iPod or iPhone.

Wearable smart technologies are considered to be a clear form of ubiquitous computing because they can accompany users everywhere (Poslad, 2009). Wearable technologies have implemented various areas including health monitoring systems, information technologies, user interface design, military applications etc. For example, Everon Corporation designed smart bracelet Vega in order to help people who are suffering from Alzheimer's disease and their families ("Vega, GPS bracelet," 2011). Vega, with the help of GSM and GPS positioning technologies allows user to walk freely in the predetermined safe zones, but raises alarm when the users leave that zone. It also inhabits an emergency button and hands free two-way communication system.

Even though ***robots*** are more complex technologies, Ma (2005) included them also as smart objects. The major difference of robots from other smart technologies is they usually can move on their own. There are many areas that robots take place; manufacturing, entertainment, military, space exploration etc. However, the capabilities of robots are limited. Autonomous and self-moving robots can do easy tasks such as vacuuming and mowing (e.g. Robomow grass mower; www.robomow.com and Roomba vacuum cleaner; www.irobot.com) but it is hard to design robots that are capable of doing more elaborate tasks such as taking care of the whole household errands. Still, Norman (2007) believes that robots can be very helpful in education even within the abilities of today's technology. He thinks that since children are attracted to quasi-intelligent toy robots; cute and lovable robots may be successful in teaching.

2.3.2.2 Smart environments

The notion of a smart environment refers to a real physical space embedded and enhanced with many mobile/fixed and interconnected smart ubiquitous things. Equipments and capabilities of a smart environment entirely depend on the aim of the environment. A smart house might be equipped with sensor and decision making technologies to adapt the preferences of the inhabitants to provide comfort. A smart classroom might be equipped with tools to capture lectures and support distance education in order to enhance learning process. Yet, all of the smart environments utilize ubiquitous computing view by enhancing everyday objects and making underlying technologies invisible.

Ma et al. (2005) designed and utilized project UbicKids; a smart hyperspace (multiple smart environments) for kids; aimed to help parents take care of their kids ubiquitously. They emphasized the acceptability requirements in utilization of smart environments -especially for kids. In order the users to accept smart environment it should be predictable, controllable and sustainable. The environment should be ***predictable***, it should be customized to adapt family culture, preferences and requirements. It should be fully **controllable**; users should be able to easily stop some functions if they find it not suitable or abnormal. The third acceptance requirement is **sustainability** which includes at least two meanings; it should make users always comfortable (environment shouldn't look strange, annoying or unfriendly) and it should cost reasonable (hardware and software systems shouldn't cost too much, in other words, they had better be general enough to make it capable of supporting the users' needs.)

2.3.2.3 Smart systems

Smart systems can be common service infrastructures such as traffic management systems, communication network systems, environment monitoring systems, information delivery systems etc. or they can be general service frameworks to support smart objects and smart environments (Ma, 2005). A summary of physical properties of smart products demonstrated in (Figure 2-10).

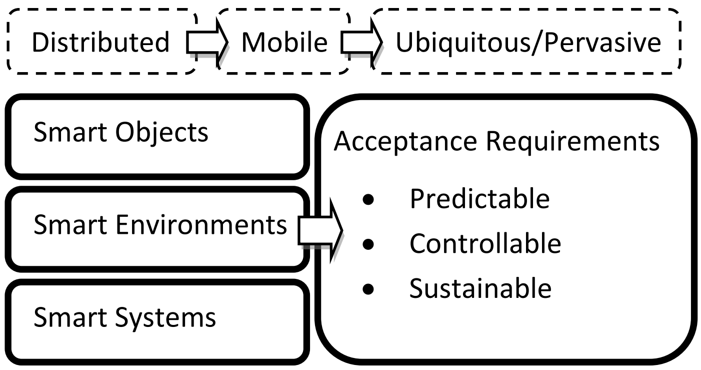


Figure 2-10 Outline of physical properties of smart products

2.4 INTERACTION

The way the user interacts with the smart technology is another important aspect. Since the technology is expected to act smart, many researchers agreed that interaction should take place in a natural way.

Heierman et al. (2002) indicated ***natural interaction*** as one of smartness characteristics because it is designed for human inhabitants, not for the computational system. Other researchers in the field also included natural interaction among smartness qualities (Cook & Das, 2007; Mühlhäuser, 2008; Rijsdijk et al., 2007). In natural interfaces, without having to learn graphical-based traditional user interfaces, users control the system naturally, with gestures.

Humanlike interaction is another option for interacting with smart technologies (Heierman et al., 2002; Mühlhäuser, 2008; Rijsdijk et al., 2007). Rijsdijk and his colleagues (2007) suggest that smart products should be able to communicate in a humanlike manner and show personality characteristics to be more compatible with users. They believe such product-user interaction is more closely resembles interaction between humans. ***Humanlike interaction*** is a natural interaction because it refers to basic interaction in between humans; voice production and recognition.

Another dimension for smart interaction is ***multimodal interaction*** (Cook & Das, 2007; Heierman et al., 2002). Multimodal interfaces allow users to interact with smart products with multiple source of input. Users can interact naturally by voice, hands and body gestures. Multimodal interfaces not only advantageous for users but also for the system. Two or more source of information reduce the uncertainty in a given input (Oviatt & Cohen, 2000).

2.4.1 Natural Interaction

Non-intelligent products are more likely to make the user to adapt the product, but an intelligent product should be able to adapt the user (Rijsdijk et al., 2007). Since people naturally communicate through gestures, movements, expressions and discover the world by looking around and manipulating things, they should be allowed to interact with technology as they are used to interact with the real world (Valli, 2008).

2.4.1.1 *Gesture based interfaces*

Saffer (2009) thinks that a new era of interaction design has begun; the era of interactive gestures. A gesture, he explains, “is any physical movement that a digital system can sense and respond to without the aid of a traditional pointing device such as a mouse or stylus; a wave, a head nod, a touch, a toe tap, and even a raised eyebrow can be a gesture” (Saffer, 2009, p.2). Gestural interfaces can be divided into two categories touch-screen gestural interface and spatial gestural interface.

Touch-screen gestural interfaces require the user to touch the product or any surface attached to it, interaction take place in 2D media. Touch-screen interfaces are already utilized in many smart-phones, PDAs and tablet PCs. In touch-screen interface simple tapping refers to clicking in the traditional mouse interface. Some products also have multi-touch features that allow users to control with multiple fingers (Figure 2-11).

Figure 2-11 Apple’s MacBook allows users to control different features with multiple fingers (Retrieved from www.appleiguide.co.uk).

In some products touch-screen interfaces aren’t limited to product’s surface such as glass screen in smart phones and touch-pad of laptops. Rather they can use any surface as a touch-screen interface by, for example, Holographic Laser Projection which is shown in the Figure 2-12.

Figure 2-12 Light Touch, can use any surface as interaction medium (Retrieved from lightblueoptics.com/products/light-touch/).

Spatial gestural interfaces acquire 3D movements remotely, there is no need to touch or handle the product. In literature, free-form, 3D gestural interface terms are used interchangeably for spatial gestural interface. A controller apparatus or a wearable technology such as glove can be used to as an input device. Familiar examples are various game consoles such as Nintendo Wii, Xbox Kinetic, Playstation 3 Move.

The researchers in the MIT Media Lab developed a gestural interactive system; SixthSense which is also mobile (Mistry, Maes, & Chang, 2009). Sixth sense not only allows users to interact remotely with finger movements but also support anytime anywhere information because it is mobile (Figure 2-13).

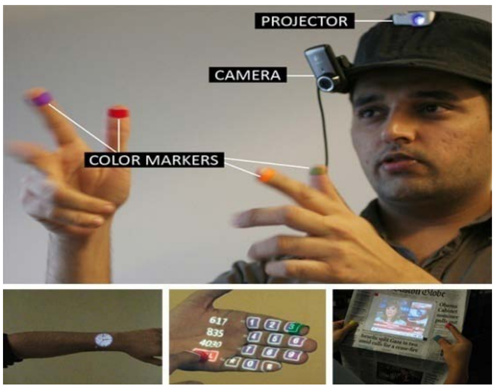


Figure 2-13 SixthSense uses color markers to recognize movement (Mistry et al., 2009)

2.4.1.2 Advanced interactions that uses gestural input

2.4.1.2.1 Virtual reality

Virtual reality refers to an multisensory, immersive and interactive experience generated by a computer (Machover & Tice, 1994) which entirely isolates users from real world. The goal of virtual reality is to induce a real world sensation through 3D visuals that can be manipulated by users. For example, in Ottawa Hospital Rehabilitation Centre, injured soldiers who suffer from post-traumatic stress are rehabilitated with virtual reality (Dhillon, 2010). It allows them to simulate almost all realistic life experiences, and push the limits of rehab training in a safe environment.

2.4.1.2.2 Augmented reality

Augmented reality is closer to the real world comparing with virtual reality. Virtual information is added into physical environment in real time via video, sound or graphic displays. Augmented reality systems can be in the form of both a transparent optic that reflects computer generated images to the user's eye and project images directly to the physical objects (Grady, 2003). There are also many smart phone applications utilize augmented reality such as Star Walk. This application allows users to point their device to sky and see indication of the stars, constellations, and satellites at in real-time ("Star Walk," 2011). Augmented reality is also adopted by professionals. For example, ARTHUR system is an augmented reality enhanced round table that allows architects to decide collaboratively on design and planning (Broll et al., 2004). While users can see the virtual buildings via 3D stereo viewer, physical placeholders that are linked to virtual models can be manipulated to change the virtual buildings position (Figure 2-14).

Figure 2-14 Architects manipulates virtual models with placeholders and gestures (Retrieved from Broll et al., 2004).

2.4.1.3 Humanlike Interaction

Bradshaw declared *knowledge communication ability* which refers to product's ability to communicate with users with language resembling human-like speech. As mentioned earlier, some of the researchers think that smart interaction should be humanlike. Some even asserted that smart product should display personality to be a credible (Rijsdijk et al., 2007). There are also studies that investigate usability of such interaction; the study on operation of ATM showed that users evaluate the use of speech as more natural (F. Chan & Khalid, 2003). Also, illiterate persons may benefit from interaction through humanlike speech (Cremers, de Jong, & van Balken, 2008).

Some smart products are already designed to communicate with users through voice production and recognition. Most familiar example is car navigation systems; it communicates with drivers through speech, freeing users to push buttons etc. while driving.

Smart interactions revisited on Figure 2-15.

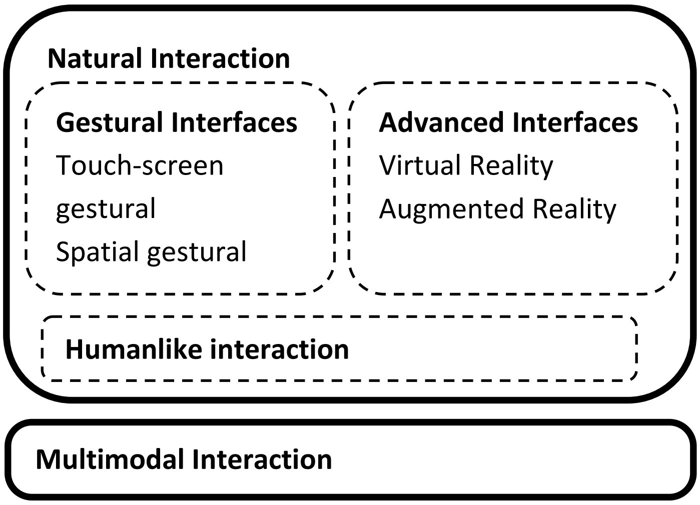


Figure 2-15 Smart Interactions

This chapter summarized capabilities and features of smart products in terms of smartness, physical qualities and interaction. Next chapter will be focus on state-of-art learning technologies.

CHAPTER 3

STATE-OF-ART TECHNOLOGIES FOR LEARNING

3.1 NEW WAYS OF LEARNING

The technological advancements affected many different fields including education. Integration of technology has been changing the face of schooling process irreversibly. New learning methodologies have been developed to enhance learning with the help of technology. The earliest one is *e-learning* (electronic learning). For Kahiigi et al. (2008), e-learning basically refers to learning process coupled with any ICT (information and communication technology). It encompasses all the technology related learning methods that emerged later on. Supporting this view, Liu and Hwank (2010) used the term *conventional e-learning* to describe first step of e-learning progress. Figure 3-1 illustrates their view; paradigm shift in learning technologies; e-learning is the first step. The tools of the *conventional e-learning* are computers (PCs, notebooks and other devices) that are connected to Internet through wired services. Thus, they are stationary learning environments.

The next step is *m-learning* (mobile learning) which benefits from mobile devices such as PDAs, smart phones, tablet PCs etc. and wireless network services. Mobile learning became a hot topic when the portable devices adopted widely among learners. Mobile technologies can be a powerful learning instrument because they are capable to provide information access for the learners when they are not in physically restricted area like schools.

Figure 3-1 The components of paradigm shifts in e-learning (retrieved from G.-Z. Liu & Hwang,2010)

Innovation in ubiquitous computing has already been integrated to education. Ubiquitous learning which is also called pervasive learning (Luo, Dong, Cao, & Song, 2010), is considered to be very promising about the future of education. With the advances in the ubiquitous computing, the field of u-learning is expanding very rapidly.

Although there are many studies in the field, there is no exact definition of u-learning. Each study adopts different levels of ubiquity understanding. A broad definition of ubiquitous learning is “anytime anywhere learning”. In that sense u-learning can take place even without the presence of mobile learning tools. Therefore, even though the u-learning term came into being after m-learning, it may encompass m-learning (Figure 3-2) (Hwang, Tsai, & Yang, 2008). More specific definition is distinguished from broad sense of u-learning and m-learning in terms of information acquisition. Sensor technologies are coupled with mobile tools to provide u-learning system which has the ability to perceive environment and learner.

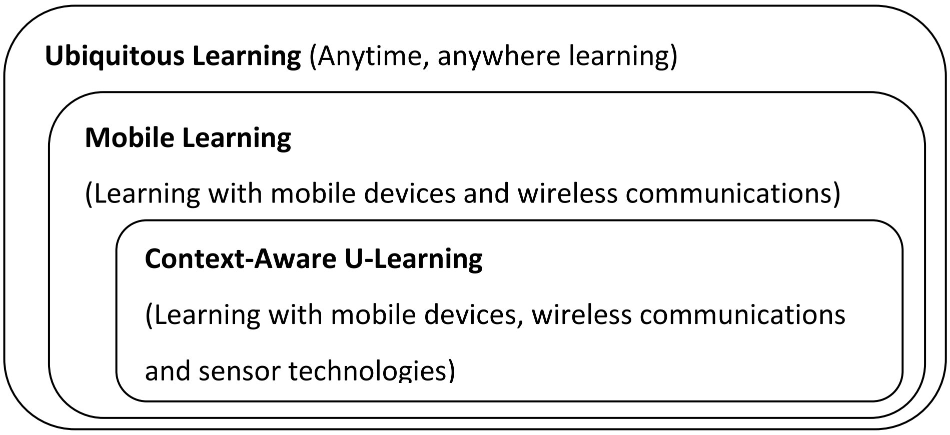


Figure 3-2 Relationship amongst u-learning, m-learning and context aware u-learning (adapted from Hwang et al., 2008)

Features of context-aware u-learning have also been mentioned at different levels in the literature. Yang, Okamoto and Tseng (2008) introduced a summative view of characteristics of context-aware ubiquitous learning as follows;

- ***Mobility****: The continuousness of computing while learners move from one position to another.*
- ***Location awareness:*** *The identification of learners' locations.*
- ***Interoperability:*** *The interoperable operation between different standards of learning resources, services, and platforms.*
- ***Seamlessness:*** *The provision of everlasting service sessions under any connection with any device.*
- ***Situation awareness:*** *The detection of learners' various situated scenarios, and the knowledge of what learners are doing with whom at what time and where.*
- ***Social awareness:*** *The awareness of learners' social relationship, including what do they know? What are they doing at a moment? What are their knowledge competence and social familiarity?*
- ***Adaptability:*** *The adjustability of learning materials and services depending on learners' accessibility, preferences, and need at a moment.*

- ***Pervasiveness:*** *The provision of intuitive and transparent way of accessing learning materials and services, predicting what learners need before their explicit expressions. (p.1)*

Its ability to be aware of location, situation and learner, distinguish context aware u-learning from all other e-learning forms. The "context awareness" property allows the system to detect the learning behavior in the real world and hence more adaptive learning activities can be conducted.

3.2 EFFECTS OF TECHNOLOGY ON LEARNING

The science of learning continues to evolve as the technology evolves either independent from each other or not. The new learning has common features with new technology because they eventually affect each other (Table 3-1).

The method of adaptive learning has been studied more than three decades. In educational aspect of adaptive learning, each learner has different abilities, experiences and socioeconomic backgrounds, so they learn at different ways, varying rates and each one requires different amounts of instructional support (Talley & Hollinger, 1998). Adaptability is also common in technology studies such as context-aware smart environments mentioned in the chapter two. The integration of technology to education further improved adaptive learning. While e-learning tools can be adjusted according to learners profile (knowledge, skills, learning history, styles, preferences), u-learning also take contextual information (social network, location, state of learner and environment) into consideration (Zhao, Wan, & Okamoto, 2010). The result is more personalized technologies that allow more individualized learning.

Table 3-1 Convergence between new learning and new technology (Adapted from Sharples, Taylor, & Vavoula, 2005; Soylu et al., 2011)

New Learning	New Technology
Adaptive	Context-aware
Personalized	Personal
Situated	Mobile
Ubiquitous	Ubiquitous
Collaborative	Networked
Learner Centered	User Centered

Advancement in technologies and their utilization to learning have led to paradigm shift from traditional to personalized learning methods (Kahiigi et al., 2008). Just like the products that allow users to personalize the content with calendars, music playlists, learning process is becoming more personalized and learner-centered. Learner-centered approach is very similar to user-centered approach in the design society. Both consider the needs and preferences of the learner/user not the ideas and experiences of teacher/designer. Each individual may have different preferred sensory modalities. Basically, perceptual styles are; ***visual, aural*** and ***kinesthetic*** (tactile) (Sun, Williams, Ousmanou, & Lubega, 2003). Adaptive and personalized features of new technology have potential of giving the content in more than one modality to address learners with different perceptual modes.

Learning should take place in the relevant context. In terms of situated learning, learners should be able to move freely to relevant places of content to be learned. For example, if the content is about plant science, the learning should take place in greenhouse, garden etc. The advancements in mobile technologies and utilization of mobile learning help to achieve the situated learning view.

Learning is not just happening in the classrooms, it is "an aspect of living not of place"(Bruce, 2009). Thus, the nature of learning is ubiquitous; it is not confined to boundaries of schools. Ubiquitous technologies are capable to provide this freedom to learners; they can deliver right learning contents at right time in an appropriate way, anytime, anyplace, any path and any pace (Zhao et al., 2010)

Learning is not an isolated activity, an individual learns from people around his/her immediate society. The father of this idea, Vygotsky introduced the importance of social environment on learning in his influential book *Mind in Society* (1978). Collaborative learning methods are developed in the light of this study. Today, the networked technologies are capable of further enhancing collaborative learning. An individual has access not only to databases but also real people through social media. Network services such as GSM and Internet are widely used for knowledge exchange in daily life and it is very promising for collaborative learning.

This section summarized the trends in learning technology; e-learning, m-learning, u-learning and the features of new learning and new technology that has potential to support learning. The rest of the chapter will cover the environments and products that utilize technology to enhance learning.

3.3 MEDIA FOR LEARNING

Throughout the educational research timeline, researchers try to find ways to enhance the learning process with developing tools and environments. Technological advancements accelerated the projects and gave rise to new fields. From classrooms that intelligently understand the gestures and commands of the users, to virtual places where learners get together with distant counterparts, learning started to occur in many complex places.

3.3.1 Smart Classrooms

Although learning can be experienced anytime, anywhere through any media, most traditionally accepted place for learning is classroom. Classrooms are evolved in time, integrated with ICT technologies to enhance learning process, reducing learner’s workload and provide remote lecturing. In recent studies, context-aware sensing methods are utilized to further improve learning experience in the smart classrooms such as signal strength tracking for speaker detection, speech recognition for interpreting voice into commands, autofocus and auto zooming for emphasizing important imagery, gaze tracking for predicting actions etc. (Pishva & Nishantha, 2008).

One of the earliest studies about smart classes took place in Georgia Institute of Technology. Classroom 2000 project -later called eClass- aimed to eliminate students' note taking during the lecture, therefore allowing them to be more focused on the content (Abowd, 1999; Brotherton & Abowd, 1998, 2004). The classrooms are equipped with technology that supports audio and video capture. The captured lecture then can be accessed through web, allowing students to rewind and repeat it. The lecturer may also make annotations on the projected presentation with a digital pen; those annotations are also captured and stored for later access. The researchers intention was not o change the traditional pedagogy of the teaching, but to ease the students' job during the lecture.

Likewise, in the Active Class Project, researchers intended to increase the student participation during the lecture (Griswold et al., 2004). Learners may be reluctant to ask questions because they may feel embarrassed in front of fellow student or they may simply think that it is challenging the authority and impolite. Considering that, in Active Class students are given wireless mobile devices that allow them to ask questions anonymously, answer polls and give feedback to the instructor. The results then can be viewed on a display by every student and lecturer. Similar study introduced in University of Nottingham, a cell phone assisted classroom interaction system (Elliman & Liu, 2007). Students gave feedback to the instructor through sending SMS.

Similar technologies are utilized in smart classrooms that are majorly intended for distance learning. Smart classrooms adopted technologies to facilitate multiple natural modalities for teaching, learning and class interactions to achieve several goals in remote lecturing; enable distance teachers to become as effective as those who teach at local classrooms, provide students with enhanced local class participation experience, ensure system security and provide access to past contents (Nishantha, Pishva, & Hayashida, 2008).

Widely cited studies took place in Tsinghua University, the researchers further developed the capturing methods to achieve real-time traditional class experience for distance lecturing. In the early studies, they developed tele-education by embedding sensors, face, speech and eye gaze recognition module in addition to cameras and projector to give space to instructor freedom with gesture based control (Xie, Shi, Xu, & Xie, 2001). In the later studies they integrated a virtual assistant with speech recognition module to the Smart Classroom (Shi et al., 2003). Before authorizing use of the classroom facilities, the virtual assistant automatically identifies lecturer by combination of face recognition and speaker-verification technologies. The virtual assistant is also capable to understand pre-determined voice commands such as “jump to the next page” or “go back to the previous page”. It also alerts the teacher about the remote students who wants to take floor. The close-up view of the live image of a remote student who takes floor is presented on large displays in the smart classroom. More sophisticated displays such as 3D imaging, which render each image as if the remote students were seated in a large hall, are emerging (Pishva & Nishantha, 2008).

When the personal mobile products, sensors and other context-aware devices became more pervasive, the equipments and capabilities of the smart classrooms have enhanced and services the classrooms give has improved. Smart classrooms have become capable to adjust themselves according to the course by identifying lecturer, students via Bluetooth or RFID tags and by previously determined system rules and timetable schedules (O'Driscoll et al., 2008). The system can be personalized by preferences of each individual. For example, each student may log on the system and choose how the lecture material is to be transmitted such as wirelessly to a laptop during the lecture, or sent to an e-mail address. Similarly lecturer may decide on who receives the lecture notes; the students present physically in the class, remotely signed in or not present. Due to the identification capability, lecturer may reveal the absent students and limit their access to course content. More elaborate decision making mechanisms integrated to Context-aware Smart Classroom in later studies (Kelly et al., 2009). The Context Aware Smart Classroom to support real-time Software Configuration is implemented to make appropriate software configuration decisions for classroom PCs that are based on situational information such as identity of the users, classroom timetables, policies and preset rules. The system is capable of recognizing different events that occur and react accordingly. For example, if a lecturer changes a session to a room other than that assigned in the timetable schedule, smart system senses this based on the information gained from the identification of class members, and automatically reconfigure the appropriate software for the PCs in the new room. All those smartness features are intended to facilitate lecturer's instruction process rather than enriching the learning experience.

3.3.2 Individual spaces to open environments

In their later studies researchers in Tsinghua University called their previous design of Smart Classroom as *individual smart space* which is limited to closed space, they proposed *open smart space* to enhance learning experience (Suo, Miyata, Morikawa, Ishida, & Shi, 2009). Open Smart Classroom mainly benefits from personal mobile devices owned by students. Its major novelty is all software modules run in software infrastructure is capable to coordinate and communicate with each other. Therefore, handle-held devices can discover the existence of smart space in context-aware manner and make use of resources and services in the space to perform tasks.

The environments and devices that support context-aware ubiquitous learning are focus of most recent studies in terms of learning technology. But some researches date back to one decade ago. The Active Campus project, the sequel of Active Class, allows students to get information about campus buildings (from a map), classes, events and communicate with nearby people through PDAs (Griswold et al., 2004). Researchers in University of Tokushima developed two ubiquitous systems to enhance Japanese language learning (Ogata & Yano, 2004). In TANGO (Tag Added learning Objects) they introduced RFID tagged ordinary objects and RFID readers to the students. The PDAs (equipped with RFID readers) guide the students and ask questions about tagged objects around the students to teach and practice Japanese vocabulary. JAPELAS (JApanese Polite Expressions Learning Assisting System) is aimed to teach about complicated Japanese polite expressions. The PDAs are capable to detect the formality in given locations via GPS and RFID tag, and informs the user. For example, when the user enters a meeting room, more formal expressions are presented in his/her PDA.

More recent studies utilize same context-aware technologies (sensors, RFID tags, wireless connections, Internet, GPS and GSM etc.). Ubiquitous learning systems become more wide spread and easy to implement as the technology used become cheaper and available. Therefore, there are many studies related to context-aware ubiquitous learning's efficiency, affects on students' engagement, motivation, achievement etc. Most of those studies make use of readily available technologies such as mobile phones and PDAs. A personalized context-aware ubiquitous learning system (PCULS) is developed recently to support vocabulary learning in foreign languages (C.-M. Chen & Li, 2010). The system gathers information about user location through GPS and other contextual information such as school time or leisure activity, and recommends appropriate English vocabulary associated with providing context-awareness information to individual learners, to support effective English vocabulary learning. One other study integrates context-aware ubiquitous system with augmented reality (again through PDAs) to increase learning by immersion as well as provide a richer learning experience (T.-Y. Liu & Chu, 2010).

3.3.3 Virtual environments

Virtual media is one other new space for learning. Virtual environments have potential to grant immersive learning experience which promotes creativity, communication, collaboration and inquiry as ubiquitous learning environments do. These environments "are virtual not by virtue of any kind of synthesized reality, as that is normally understood, but in relation to dynamics of interest, involvement, imagination and interaction that support an active engagement between learner and a learning environment" (Burblues, 2009).

Virtual worlds that are created and designed for online computer games, allow users to adopt online identities called avatars, interact with other players using their avatars, accomplish tasks and explore the environment. Moreover, those places are designed not necessarily with the strict rules, specific outcomes or defined winners and losers. For example, *Second Life* is one of the most popular and populated virtual worlds and subject of many studies in literature of learning technologies (De Lucia, Francese, Passero, & Tortora, 2009; Jarmon, Traphagan, Mayrath, & Trivedi, 2009; Warburton, 2009). In the case study that took place in University of Illinois; students spent time, interact with other players and presented their artworks in virtual environment of *Second Life* (Craig, Downey, Garnett, Mcgrath, & Myers, 2009). Researchers assert that virtual world is easy to learn, fun to experience, safe, easy to contact with large communities and provides greater sense of being there via shared experiences with other players. *Second Life* is an example of 3D simulated world designed for mainly adults, and the participants of academic studies are mainly from higher education. On the other hand, many virtual worlds designed for children and adolescents are available (e.g. *Club Penguin, Webkinz, Habbo* etc.) and continue to emerge (Shuler, 2007). Researcher claims that the educational potential of virtual worlds is huge for children who already internalize digital media as a norm.

Digital games constitute another virtual media that have potential for learning. Digital games also known as **serious games** are computer and Web-based games designed for primarily educational purposes rather than entertainment (Rapaport, 2008). Games are good media for *stealth learning* in which students learn without realizing that they are learning because the content and skills are embedded within the activities of the game (Maloy, Verock-O'Loughlin, Edwards, & Woolf, 2011). Sid Meier's Civilization, is one of the most immersive and popular historical simulation game that allows players to observe historical timeline while building societies through exploration, war and management of new technology from alphabet to nuclear power.

3.4 TOOLS FOR LEARNING

New technology gives rise to the new tools for learning. Technological progression directly reflected to educational researches and learning technology market. Televisions, projectors and computers are part of the education for a long time in many classrooms around the world. Today, more advanced tools have already started to take place in learning environments.

3.4.1 Interactive-whiteboards

Projectors coupled with computers were remarkable innovation when they enter classrooms nearly a decade ago. They are capable to project any image found in computer (and Internet) in a large scale, especially visual learners benefitted a lot. Their visualization feature not only enriches the instruction in a multimodal manner, but also eases the lesson preparation for the instructor. However, it is hard to manipulate the prepared course material during the instruction because the instructor or student has to use computer to interact with the technology which is a limiting factor teaching. Interactive-white boards (IWBs) closed this gap with their capability to provide more natural interaction. IWBs' novelty is touch sensitive electronic board that allows the user to write on digitally. Users can write on the computer image projected to electronic wallboard with their bare fingers or other tools such as digital pen. Also, recently large screen LCD displays with a touch-screen cover are used instead of electronic board coupled with projectors.

Users can interact with the technology in a natural way, as they do with chalkboards, also gesture-based commands are recognizable such as drag and drop, erase with palm etc. Some versions of IWBs have multi-touch feature that lets more than one student to interact with board (Figure 3-3). In recent studies it is shown that IWB's visual capabilities, access to vast information sources (via internet) and nature of interaction make it useful and motivating tool for education (Higgins, 2010; Wood & Ashfield, 2008).

Figure 3-3 IWBs support gesture-based natural interaction. (SMART Board®; Retrieved from www.smarttech.com)

Furthermore, software tools and activities can be installed to the smart boards. Software offers not only graphical tools to draw easily and write intelligibly but also interactive learning objects to engage learners. Some software tools and games advertized by PolyVision Company are as follows;

- *Drawing tools; select arrow, undo, line tools, eraser/delete, shapes tools, text, color settings, highlighter and image bank*
- *Video and Screen tools; video device (input from any webcam/video device), screen capture (region or screen), screen recording (from video device or entire screen), journal of saved images/recordings*
- *Literacy tools; text tool, journal, word and sentence builder, punctuation tool, collect highlighting tool, mind map tool, word roots tool*
- *Literacy Games; letter blocks, word hunt, mix-up, scramble*
- *Number tools; dynamic numbers with on-screen calculations, function machine, dynamic abacus, dynamic customizable number lines, fully customizable numbers grids, interactive fractions, calculator*
- *Graphic and data tools; probability spinner, dice, tally, graphs with line, bar, column and pie charts*
- *Math games; arithmetic game, speedy sums, math lines, number balls, see-saw, memory*
- *Measurement tools; ruler, 180 and 360 degree protractors, compass tool (properties of circles), conversion tool, analog and digital clock, calculators, stopwatch, tape measure("WizTeach Educational Software Tools")*

Components that increase the efficiency of the teaching with IWB are developed in time. For example, tablets are developed to free the users from the limited usage area of the IWB and allow them to manipulate the IWB remotely. The designers of Promethean Inc. presented a digital pen to use with IWB, claiming that educational specialists suggested them children's writing is best developed by holding and using pen from a young age.

3.4.2 Interactive response systems

Interactive response systems also known as *student participation systems, personal/audience response* systems or just *clickers* are handle held wireless tools that allow participants to vote on a topic or answer a question instantly and remotely (E. S. K. Chan, 2009). The questions can be multiple choice, yes-no, true-false, ranking numeric or short answers depending on the model of the device. Instructor prepares the questions with the help of system's software, then the computer connected responder system's main unit collects the answers wirelessly (via infrared, Bluetooth or radio frequency) from all the clickers (Maloy et al., 2011). Once everyone enters their answer or vote, the results are instantly visible, showing the correct answer and the percentage of learners in the class who picked each answer. There are simple models of response systems designed for easier use of younger students, also response systems can be installed as an application for smart phones or tablet PCs (Figure 3-4).

Figure 3-4 Simple and elaborate response clickers and response application for smart devices (Respectively; Promethean ActivExpression and ActiVote retrieved from www.prometheanworld.com; SMART Response VE retrieved from www.smarttech.com)

Interactive response systems have several advantages in learning context (Bruff, 2007; Maloy et al., 2011; Stowell, Oldham, & Bennett, 2010).

- Students feel more comfortable when they answer anonymously with response systems. Since the learners worry less about the embarrassment of giving a wrong answer, more students participate the than traditional oral discussion.
- Instructors have immediate feedback about the condition and level of the audience.
- Students will participate more actively because in theory, they feel that their ideas are matter.

3.4.3 Audio amplification system & Document camera

Tools are developed to enhance learning environment by removing barriers that hinder learning process. Most popular ones are audio amplification systems and document cameras.

The classrooms may be crowded and noisy sometimes. This adversely affects the learners, especially *aural* learners and can be tiresome for both the teacher and students. Audio amplification systems can be installed to overcome problems such as ambient noise, distance and reverberation. Also, audio amplification systems can counteract with weak lecturer voice levels by increasing the speech level, resulting a nearly uniform speech level throughout the classroom (Flexer, 2005).

In his study, Heeney (2007) suggested installation of audio amplification systems to all elementary schools to reduce disparity among students and improve learning outcomes for all young learners. His results revealed that those systems can enhance listening and learning environment and have potential to raise the achievement levels of the children in listening comprehension, reading comprehension, and reading vocabulary which has a flow-on effect on the overall scholastic achievement of all students.

Document cameras also known as *image presenters, visual presenters, digital visualizers, digital overheads*, and *docucams*, are devices used to capture images and present it in a larger display. It basically consists of a webcam and arms to hold the webcam. It can be used to present not only printed material, but also objects. Documents cameras can be a good alternative of standard overhead projectors which are only capable to display transparencies.

Document cameras can be useful in many scenarios; for example, learners strive to see the scene when a science teacher performs an experiment, it is nearly impossible for each student to follow the event with equal circumstances. With the help of such camera, students may watch the experiment even when they are seated. In addition, some versions of the document cameras are compatible with IWBs, computers or printers. This quality allows user to store the captured information for later use. High zooming capacity of some models allows the audience to see the smallest details ("SMART Document Camera," 2011).

It is worth to mention that the success of these systems strongly depend on the teaching strategies and other factors. They are only capable to remove a barrier of learning.

3.4.4 Interactive Surfaces

There are many hands-on tabletop technologies developed in design studios of different companies; Microsoft's Surface, Panasonic's Interactive Table, Philips's Entertaible, Mitsubishi's DiamondTouch etc. Some designers focused on educational potential of such products. Even thought there are few products marketed for use in school context, many concept designs are presented in exhibitions and some other examples are installed to museums.

Potion Design developed two educational tabletop projects for Museum of Science and Industry. "*The Chemistry between Us*" project is aimed to teach about hormones; connection between chemistry and the various emotions of love ("Chemistry between Us," 2011). *"What is in Your Blood?"* interactive table lets the children explore blood stream; realistic 3D renderings of different blood cells and molecules that can be discovered through virtual hand-held magnifying glass (Figure 3-5) ("What is in Your Blood," 2011). By placing hand beside a giant heart; users can synchronize their own heart rate with that of display.

Figure 3-5 Interactive tables (Retrieved from www.potiondesign.com)

Another tabletop technology with educational purposes is “Chemieraum” developed in TUMlab (Experimental laboratory in University of Technology, Munich) (Glaeser & Franke, 2008). The concept designed for teenagers to learn about chemistry by interactively playing with atoms and molecules. It allows users to create molecules using the five basic elements; hydrogen, oxygen, nitrogen, carbon and sulfur. The novelty of the product is user receives haptic feedback from the “*puck*” which is used to navigate the product (Figure 3-6, left). For example, if the atoms or molecules are warm, e.g. the boiling point, puck begins to vibrate and change color. Moreover, the *puck* resists when the user wants to combine atoms into molecules that is impossible in nature ("Interactive table concepts collection", 2009).

Figure 3-6 Chemieraum (Retrieved from www.chemieraum.com), SMART Table (middle and right, Retrieved from www.smarttech.com)

Smart Technologies Inc. introduced SMART Table as a marketable product for schools, focusing especially on young students (Figure 3-6, middle and right). The features of this interactive table are a lot like interactive smart boards, but the table structure allows children work together. The producers claim that installed activities and games help children learn age-appropriate skills, such as reading and counting, through collaboration and critical thinking. Since the user group is children, designers planned a durable construction for the table, it is said to be resistant to bump and accidents.

3.4.5 Applications for personal technologies

Contemporary children possess many personal devices such as desktop PCs, notebooks, multimedia players or smart phones. Learning through these technologies becomes more and more popular each day. There are many multimedia designed for computers such as videos, games, activities, animations, weblogs, and podcasts. The major advantage of computer multimedia is that it provides one to one instruction and lets learner to set his/her own pace. For example, a student may choose to watch a video over and over again since s/he fully understands the content. Also, Internet provides anytime, anywhere access to many contents in a ubiquitous manner.

In the era of ubiquitous computing, applications (abbreviated as apps) have great potential to turn mobile smart devices into a learning technology. Companies such as Apple Inc. and Google Inc. have already harbor thousands of third-party applications that contribute to the educational market. Variety of applications is available in the virtual stores; from game-based activities to augmented reality. Following examples from Apple and Android stores illustrate diversity of the applications designed for smart phones and tablet PCs;

- *Intro to Letters*; is an application that utilizes sight, sound and touch to help children to learn to read and create the letters ("Intro to Letters," 2011).
- *How Rocket Learned to Read*; is one of the top five book application which is aimed to teach children to read with lots of animations and interactivity ("How Rocket Learned to Read," 2011)
- *History: Maps of the world*; shows historical timeline with maps at different eras and places (Cho, 2011).

- *Molecules*; allows users to view three-dimensional renderings of molecules and manipulate them ("Molecules," 2011).
- *MathBoard*; is a math learning tool that teaches simple to complex math problems ("MathBoard," 2011)
- *SketchBook Pro*; has a potential to replace regular drawing book and crayons. It is a painting and drawing application that allows natural sketching tools. User can work in multiple layers and undo/redo the work ("Sketchbook Pro," 2011).
- *Symphony Pro;* is a music composition application that utilizes almost any instrument, allowing users to write and play back music ("Symphony Pro," 2011).
- *Star Walk and Google Sky Map*; are augmented reality applications that allows users see the stars, constellations, and keep track of satellites in real time when pointing the device to the sky ("Google Sky Map," 2011; "Star Walk," 2011).

The applications designed to facilitate users' job and enhance learning has also became focus of academic research. An application is developed for Kore University campus, aimed to inform students, professors, researchers about the classes, exams, educational, scientific activities and events that take place in campus (Collotta, Pau, Salerno, & Scatà, 2011). The application also provides a geo-location feature which give directions of University facilities and means of transport. They point out that the overall impressions of the users are positive, because the application facilitated their studies.

Although there are many applications in the market aimed for K-12 education, there are few publications study those applications. One of them surveyed a game-based application called Candy Factory designed to teach fractions to the middle-school children (Aslan, 2011). The developer/researcher asserts that the application makes the learning experience enjoyable by providing real life situations, which help the student gain hands-on learning experience.

Furthermore, the potential of applications has already started to be exploited in academic world. Apple Inc. launched *iTunes U*, a service to distribute and manage educational contents for students within universities. It is said to be more than three hundred thousand free course lectures, videos, readings, and podcasts from universities and institutions all over the world are available in the iTunes U("Apple in Education," 2011). Academic research databases such as EBSCOHost, Scopus, ScienceDirect make use of applications in order to provide seamless access to publications.

3.5 CONCLUSION

Sharples et al (2005) and Soylu et al (2011) illustrated the convergence between technology and learning (Table 3-1). The contemporary technologies used for learning affirmed this convergence; Table 3-2 illustrates this with related examples. Learning becomes more **adaptive** as the **context-aware** ubiquitous systems such as Open Smart Classroom project (Section 3.3.2) become more prevalent. Learners receive more **personalized**, self-paced instruction as they learn through more **personal** technologies such as personal PCs and smart phones. Media and tools embedded to personal technologies such as videos, podcast, games, activities, animations and mobile device applications allow them to adjust the instruction at their own level.

Learning becomes more **situated** and **ubiquitous** as the learning technologies become **mobile** and have the capability to provide anytime, anywhere information. Mobile applications allow them to be informed in any specific context via technologies such as augmented reality. Moreover, learners find opportunity to **collaborate** not only with their immediate environment, but also with counterparts across the continents with the help of **networked** technologies such as virtual environments. Then, technologies compete with each other to be more **user-centered** to be preferred. Likewise, the way that they give educational content becomes multimodal to focus on the perceptual styles of the user, to be **learner-centered**.

After scanning diverse learning technologies, the previous list adapted from Sharples et al. (2005) and Soylu et al. (2011) can be expanded (Table 3-2). Technologies become more **pervasive** each day; they get into classes to remove contextual limitations such as crowd and noise. Technologies such as audio amplification systems, interactive response systems and document cameras help the students to have equal opportunities and receive homogeneous instruction. When **engaging** technologies such games and augmented reality are used for learning they have potential to **motivate** the learner. While technologies are designed to be more **useful** and capable to do more than one task (**multifunction**), learning becomes more simplified. For example, when a student tries to learn an abstract concept via an interactive table, s/he interacts with table easily in a natural way because it is usable. It will take less time to understand because it visualizes the abstract concept and also user waste no time to learn how to use it.

Table 3-2 Convergence between new learning and new technology revisited

New Learning	New Technology	Example
Adaptive	Context-aware	Ubiquitous systems, Mobile apps.
Personalized	Personal	PCs, Smart phones, Interactive response systems
Situated	Mobile	Mobile apps., Augmented reality
Ubiquitous	Ubiquitous	Ubiquitous Systems, Mobile apps.
Collaborative	Networked	Virtual environments, Smart classrooms
Learner Centered	User Centered	Multimodal technologies; videos, activities
Homogeneous/Equal	***Pervasive***	*Audio amplification systems, Interactive response systems*
Motivated	***Engaging***	*Applications, Games, Interactive surfaces*
Simplified/Facilitated	***Usable & Multifunction***	*IWBs, Smart Classrooms*

This chapter illustrated the state of art technologies for learning and convergent features of new technology with learning. While learning technology literature and present learning technologies point out those features, the expectation of children from those technologies are missing. Next chapter will focus on the perspective of children about expected features of learning technologies.

CHAPTER 4

CHILDREN'S EXPECTATIONS FROM LEARNING TECHNOLOGIES

4.1 DESIGNING FOR CHILDREN

Like all the other technologies, educational technologies are affected by the technological improvements and most of them developed and designed by the effect of technology push. From early designers to contemporary ones, designers of smart educational products and environments adopted technology-driven design mentality (Abowd, 1999; Pishva & Nishantha, 2008; Xie et al., 2001). However, technology driven designs are restricted to the mental models of the designers and the use context that the designers are most familiar with (Kankainen & Oulasvirta, 2002). Obviously, the children are not usually among those familiar groups unless an observational study is conducted.

It is important to explore the needs and expectations of the user groups -in this case children- in order to guarantee the user satisfaction and therefore the market success. Besides, in the case of developing educational technology, it is even more important to focus on children's needs and expectations, since their frustration or disappointment may negatively affect their conception of learning.

Children have different mental models than adults; it is not easy for adults to anticipate their needs. Besides, today's children who grow up using and experiencing every kind of technological products are very different from today's adults who weren't exposed to such intense technology during their childhood (Prensky, 2001). Therefore, there is an obvious need for including children to design process of technologies, especially the ones with educational aims.

Although including children to design process dates back to 1980s, the mile stone publications emerged at late 90s; considering children as a design partner (Druin & Solomon, 1996) and consulting children as a part of informant design at the various steps (Scaife, Rogers, Aldrich, & Davies, 1997).

In her later study, Druin (2002) presented a good summary of studies that include children in design process in historical timeline and identified four roles for children in design process;

- As a *user* children are used just to understand the impact of existing technologies, so only the future products can be changed accordingly.
- In the role of *tester*, children test the prototypes and give feedback to change the future iterations of the pre-released technology.
- In the role of *informant*, children contribute the design process by informing at various steps; from the beginning to the end.
- As a *design partner*, children take part throughout the entire design experience and considered to be equal stakeholders as designers.

While each role has differences, each one includes previous one, Figure 4-1 illustrates this graphically.

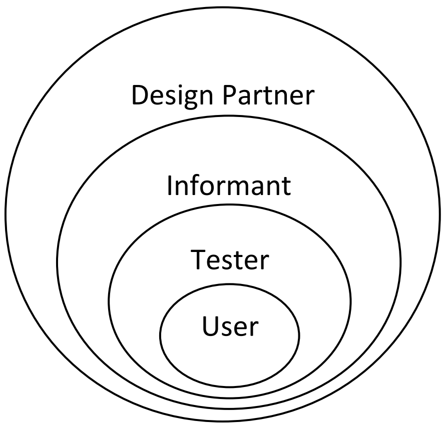


Figure 4-1Four roles of children in design of new technologies (Reproduced from Druin, 2002)

Even in the most recent studies about new technologies for children in the field of educational research community; children are consulted as *users* (e.g. El-Gayar, Moran, & Hawkes, 2011; Lin, 2011). Those studies are mainly aimed to find out the learning outcomes, and give suggestions about not only the design of the product but also the methodology from educational perspective. The suggestions and lessons learned from their designs can only be applied to future products and systems.

Instead of the finished products, prototypes that are already designed by adults are tested by the children in the role of *tester*, in order to evaluate the designed product before introducing it to the market. In a way designers test how much their idea and usage scenarios are overlapped with children's (e.g. Bekker & Eggen, 2008; Humphries & McDonald, 2011). However, sometimes prototypes that are tested and found promising, may fail in the market (Peffers & Tuunanen, 2002). Therefore, it is important to take the intended user into account in the early stages of development to convert the design process into an informing activity which in turn leads to less iteration (Kujala & Mäntylä, 2000).

Scaife et al. (1997) were the first researchers who called children as "native informants" and consulted them from the very beginning of their design research. According to them, children, based on their experiences, are capable of telling the designers what learning methods are effective, what motivates them, what keeps them engaged, what sort of feedback is fun, what encourages learning etc. and can lead the design from the first steps (Scaife et al., 1997). In the role of *informant*, children can contribute the design and development process at the key points and at the same time this method is flexible to work with short-term projects and capable to give quick findings about child's needs and preferences (Hourcade, 2008).

As the pioneer in the field of *design partnering* with children, Druin (2002) asserts that children should be equal partners (for example; they will be paid as other partners) with adults and should take place throughout the design process unlike the *informant* design. This view has became very widespread and adopted by many researchers who aimed to design specific products that serve a specific need; from medical applications to educational ones (e.g. Guha, Druin, & Fails, 2008; Ruland, Starren, & Vatne, 2008; Tarkan et al., 2009) and many of them further elaborated this topic and proposed new methods (e.g. Garzotto, 2008; Walsh, 2011).

Scaife et al. (1999) emphasize the importance of when to include children to design process, because unlike *design partnering*, in *informant design* children are involved in specific key steps, when the designers need to be informed. This is one of the challenges of child as *design partner* view, since sometimes it may be hard to bring children in research environment and may not be feasible with limited resources (Druin, 2002). Although *design partnering* with children is very promising method for designing specific product, it is not as practical as *informant design* when it is aimed to find about more general view. *Informant design* allows designers to get first hand insights of the children's world in a quick manner (Mazzone, Read, & Beale, 2008).

The aim of this study is to find out the needs and expectations of children from smart products that enhance learning; it is not aimed to design a specific product but to gather general view of the future smart products to provide initial ideas for further studies. Therefore, the child as *informant* view is adopted which is found to be appropriate for early stages of design process (Read et al., 2002). In the following section, an empirical study about the topic will be presented.

4.2 EMPIRICAL STUDY

4.2.1 Method

Interview is one of the most important research tools of user-centered design which is generally preferred for detailed information from individual users (Courage and Baxter, 2005). In their study about effectiveness of requirements elicitation techniques, Davis et al (2005) concluded that interviews are significantly more effective than several other techniques cited in the literature (such as card sorting, ranking or thinking aloud). Moreover, it is a strong method for innovation, in the early phases of new product development it allows designers or researchers to obtain a holistic view; integrated perspectives of multiple user types (Courage and Baxter, 2005). Thus, interview method is adopted as a research tool in this study in order to understand children's perspective in their own words about ideal learning technology.

30 middle-school children were interviewed to achieve statistically meaningful analysis. The focus of the study is learning technology for K-12 level. The skills and

abilities of the children in that group vary. Previous observations showed that older children in that group are more aware of their needs and capable of expressing their thoughts better and easier than younger ones. Therefore, middle-school children, ages between 12 and 14 are picked as respondents.

Availability sampling method is utilized for assigning interviewees because it was very hard to reach and occupy children. The interview sessions lasted averagely in half an hour. This made the interviews impossible to take place in schools, because most of the students don’t have that long leisure time at the school. For that reasons, respondents are accessed through acquaintances and interviews took place in the children’s home and some other familiar places such as parent’s office.

The children in the sample are from different backgrounds; some of them attend to state schools, others to private schools. Also, respondents live in different locations; different parts of a crowded city, Ankara and a relatively small city, Isparta.

Although the interviewees are belong to different schools and locations, they’re socio-economic status were not so diverse. Depending on the observations of the researcher, all of the respondents belong to middle-class income. All of the children were familiar with PCs, laptops and game consoles. Most of them were familiar with smart phones and tablet PCs. This information acquired during interviews, respondents constantly referred to those technologies.

Children were interviewed one by one, to eliminate the probability of influencing each other and peer-pressure. They were asked to design a smart tool that will help them in school and in learning process in many ways. The phrase “smart tool” is asked deliberately because smartness is associated with latest technology especially in market and advertisements. They were encouraged to think creatively -as if there is no technological or financial limitations- what would motivate them to learn, facilitate their learning process and make them more eager about learning. After they told about their ideas in general, by going over each course they take in the school (mathematics, science and technology, Turkish language, foreign language, social sciences, music, visual arts, physical education, technology and design), they were induced to add new properties to their idealized products.

Laddering technique was utilized in a structured interview in order to understand the reasons beneath the designed properties, each expected property revealed a need of the child. When the respondents had difficulties about finding product properties, they were encouraged to think their current course of lessons and then they were asked which part of the lesson they would want to change with that technology.

4.2.2 Analysis

The data obtained during the interviews were voice-recorded and transcribed into text (for sample interview see appendix). Children's explanations divided into meaningful segments and coded depending on different types of expectations. In each step of coding process, an expert checked, clarified and modified the constructs and groups. As a result of in-depth analysis and consensus with the expert, the categorization became its final version.

Since laddering technique is utilized, children were asked why they designed each feature. The reasons behind the expected qualities were the source of coding. For example, one of the respondents offered personal computers for each student and he was asked why he preferred personal computers. He gave reasons as follows; "it would help us to draw and write better" (*assistive* construct), "it would show the blackboard, so that we could see it even we were sitting at the back rows" (*contextual limitations* construct), "we wouldn't have to carry heavy books" (*ease of carrying* construct) etc. Coding is resulted 32 different constructs, and those constructs are *pattern coded* and categorized under three main groups(Miles & Huberman, 1994).

Categorization is shown in the Table 4-1. Firstly, constructs are grouped into sub-groups depending on their common traits. For example, all constructs that are designed to ease the jobs of the student (ease of carrying, ease of access etc.) are collected under *facilitative* sub-group. Then, those sub-groups categorized under three main groups; smartness properties, physical properties and methodology. The expectations related with interaction are covered as a different section. This is because interaction preferences are identified by a direct question "how would you interact with this object?" in contrast to constructs which are identified by children during elaborating on their designs.

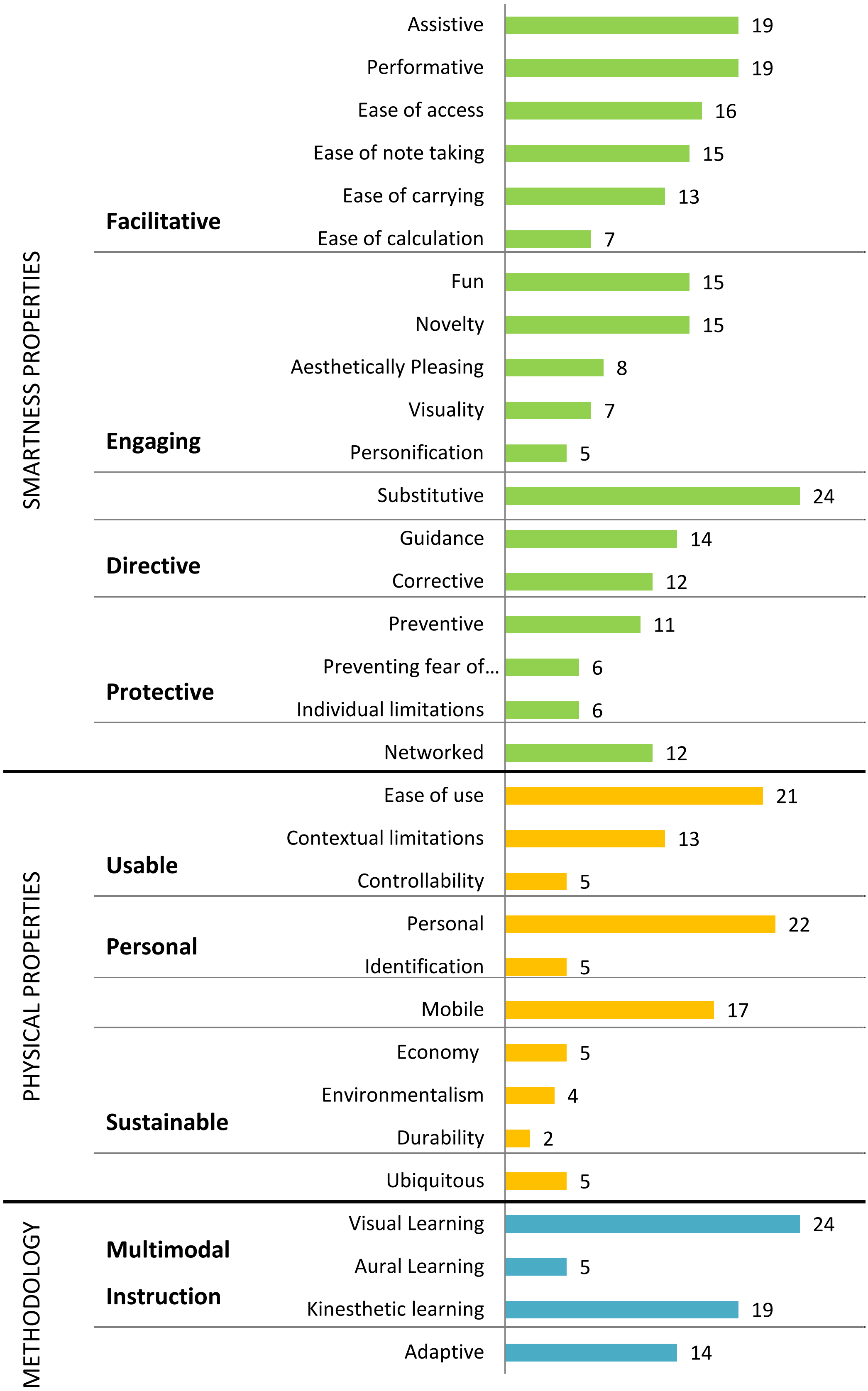
Table 4-1 Groups of expectations

Smartness Properties	Physical Properties	Methodology
Facilitative	Usable	Multimodal
Engaging	Personal	Adaptive
Substitutive	Mobile	
Directive	Sustainable	
Preventive	Ubiquitous	
Networked		

4.2.3 Results

The frequencies of each construct and their sub-groups are illustrated at Figure 4-2. Frequencies show how many children mentioned those properties, not how many times those properties are repeated. Therefore, the maximum number is 30 which is the number of respondents.

Figure 4-2 Frequencies of constructs



4.2.3.1 Expectations related to smartness of the product

The educational tools designed by children are smart in many ways. Ideal tools can prevent children from unwanted situations, assist them in their work, guide and correct them, make many things virtually available and most importantly engage them and facilitate their duties.

Following sections will scrutinize those smartness properties in detail, from most wanted to least.

4.2.3.1.1 Facilitative 93%

Facilitative group of smartness basically refers to the properties that facilitate children's duties and/or perform tasks instead of them. 90% of the children mentioned facilitative characteristics in their designed products. There are six subcategories under the group;

4.2.3.1.1.1 Assistive 63%

Children embedded features that give assistance in many ways. Those features help with the duties of the children such as drawing a proper circle with a drawing program, writing more legible with word processer programs. They claimed that kind of programs help them to present what they imagine in a better way (especially in creative projects).

They also mentioned properties that will warn them when they forget to do something, suggest what to do, where to go etc. Thus, all properties are designed make their life easier by giving assistance.

- Map of school embedded to tablet pc, showing where the next lesson will take place (in some schools, each lesson take place in different classrooms)
- A reminder program
- A program that gives suggestions to be healthy
- A pen that helps to write more understandable
- A program that helps to draw and present the drawing in a better way
- A program that writes musical notes as child plays instruments, to ease composition

- A tool that lights the key that child need to press, to ease playing melodica

4.2.3.1.1.2 Performative 63%

Children designed smartness properties which are capable of doing children's duties instead of them and release them from their responsibilities. Actually, most of those duties and responsibilities are part of their learning in the school context, therefore this construct embodies smartness properties like a magic wand that make learning happen without any effort.

Some examples from *performative* features of designed smart technologies;

- A program that reads book, reasoning that reading book makes their eyes hurt
- A system that tells child what to do when s/he is doing a research for a homework such as "read this first, then write this etc."
- A smart board that shows them how to design and apply an experiment and the result of it before they started to do the experiment,
- A smart pen which reads and summarizes topics found in encyclopedia
- A system that records the scores and the moves during playing chess
- A tool that perceives what user imagines and projects it

More radical designs;

- A robot that plays musical instruments and paints instead of them,
- A microchip that contains all knowledge about lessons, inserted to child's brain with an operation
- A robot that make their brains to absorb the knowledge

Nearly all of *performative* properties are about physical and mental obligations/duties that children should do as a student.

4.2.3.1.1.3 Ease of access 53%

Children expressed their need of reaching correct information easily and swiftly whenever they need. Most of them complained about confronting with redundant and high level information when they "googled". They designed tools that inhabit rich databases that offer information that is suitable to their level. Besides, they have a lot of ideas about how easily and fast they can access the information. Here are some designed properties related with *ease of access*;

- A dictionary program that contains all languages
- A database that contains all the information about lessons
- A program that presents all of the useful web pages related with courses
- A database of history, that helps to find out easily what historical event happened when
- A robot or a pen that knows everything like an encyclopedia, answer whatever they ask

4.2.3.1.1.4 Ease of note taking 50%

Half of the children mentioned properties that either totally eliminate or ease the note taking process during the lessons. They reasoned, while they take notes in traditional methods (pencil and paper) their hands get tired, they cannot be able to catch up with the pace of the teacher and they miss the important points that the teacher gives while they are engaged with writing. Some properties related with *ease of note taking*;

- Video and audio recording instead of writing
- Pre-prepared written documents sent by teacher virtually
- Note taking on a computer/laptop or a tablet
- A smart- pen that writes on its own
- A computer that understands what child thinks and writes those thoughts.

4.2.3.1.1.5 Ease of carrying 43%

Nearly half of the children complained about the extremely heavy bags that they are obliged to carry. They carry not only the books needed for school lessons, but also for solving tests. Most of the children propose a technology that contains all kinds of books and notebooks in it. Moreover, the technology they designed either very light or attached to the tables in order to provide *ease of carrying*. Here are some designs;

- A hologram machine that creates musical instruments that release them from carrying instruments.
- A pen which can paint in any colors, releasing them from carrying painting materials
- A program that allows painting, playing instruments virtually

4.2.3.1.1.6 Ease of Calculation 23%

Some of the children didn't skip to embed a calculator to their product. Few of them designed more elaborate ones such as

- A calculator which measures applied force and/or density of a substance in experiments.
- A calculator that perceives the problem from child's mind and solves it.

4.2.3.1.2 Engaging 80%

Most of the children (80%) complained about how boring the school is and they designed engaging features to their idealized smart technologies. With respect to their answers, five engaging factors are identified; fun, novelty, aesthetically pleasing, visuality and personification.

4.2.3.1.2.1 Fun 50%

As expected from children, they want to have fun, either during the lessons or leisure times. The ones that design engaging features for lessons indicated that if they have fun, they stay more focused to the subject. Other ones designed features for leisure times like playing games during the breaks. They define many features that make them have fun;

- Cartoon characters as virtual teachers
- A funny robot as a teacher
- Home works assigned as computer games/ games themselves teaches the subject
- A projected virtual teacher who has strong sense of humor.
- A tool that make child fly (playing games during breaks)

4.2.3.1.2.2 Novelty 50%

Interviews revealed that children think novel products and properties make them more engaged with learning process. Using a novel technology is on its own an engaging factor. One of them expressed his thought as follows "if a computer would instruct us, I would definitely stay awake and listen to it, because it is technological". According to children, the novel and therefore engaging qualities and products are as follows;

- Touch-screen interface (in every kind of technological product that children designed such as interactive board, computer/laptop/tablet, smart desk etc.).
- Talking map/wand/pen
- Virtual tutor/robot instead of real teacher
- A tool can produce holograms that can show anything in 3D

4.2.3.1.2.3 Aesthetically Pleasing 27%

Some of the children defined properties that please them aesthetically, telling that their current course of lessons and technologies that are used are dull and boring. One of the 6th graders said that "if our teacher were a cute robot, I would go to school just to see it". The other properties related with this construct are;

- Metallic colored robot teacher who has robotic voice
- A robot teacher that has colorful blinking lights on it
- A computer in colors of the rainbow
- Tablet pc in red color (reasoning that red color is very hale color and makes the user hale too.)
- Slideshows presented with colorful writings

4.2.3.1.2.4 Visuality 23%

Most of the children mention their need for visualization. 87% of children designed properties that allow visualization. But only 7 children indicated that visual materials make them stimulated. The others emphasized the importance of the visuals in their comprehension.

- Projections or IWBs to present visuals

- Historical movies instead of history lesson
- 3D animations of experiments

4.2.3.1.2.5 Personification 17%

Especially children attended junior class mention this construct. One of the children designed a program which talks and guides the child as a friend and mentor, providing feedbacks like "do you understand?", "Would you like me to help you?", "Well-done" etc.

- Virtual friendly tutors
- Friendly robot instructors
- Talking cute cartoon characters
- Talking geometrical shapes (introducing itself to child)

4.2.3.1.3 Substitutive 80%

This construct is harboring the designed properties that are aimed to diminish differences between schools and instructions. Designed tools and/or properties provide more standardized education.

Not every school has same opportunities. Many children pointed out absence of laboratory materials, instruments and other stuff. As member of school's chess club, a boy said that there are no chess set in their school; therefore they can do nothing during the club hours. They designed many properties to make up for these absences.

- Virtual chess set
- Virtual laboratory materials/ doing experiments virtually
- Virtual musical instruments
- A robot that can answer any question/ knows everything (absence of resources such as encyclopedia or internet)
- A hologram machine that can turn an empty area into field for different sports

Children not only designed for compensating the absence of materials but also for the deficiencies of the teacher and student.

- Virtual tutor that instructs in the absence of teacher

- Virtual tutor that speaks very good and fluent English (reasoning that their English teacher isn't sufficient)
- Virtual teacher who knows everything, can answer any questions and available anytime
- Robot teacher who never gets tired (reasoning that some teachers never let the students do experiment, telling them s/he is very tired.)
- "If every class have the same robot teacher, every one receive same education, it would be more just."

4.2.3.1.4 Directive 67%

4.2.3.1.4.1 Guidance 47%

Children stated that they need guidance especially in creative tasks. In their Technology and Design course, they are expected to detect a problem and find solution. Also in visual arts course, they are expected to imagine a composition related with given topic and draw accordingly. However, nearly half of the respondents seemed to be unwilling to take part in this. They designed databases which provide older projects, other project ideas and pictures to "inspire" (in their words) them. They also suggested guiding systems that warns them about important points during the instruction.

- Database that has pictures/images in every style and topic.
- Virtual tutor telling him/her what to draw, which colors should be used where
- A machine that provide project proposals for Technology and Design lesson (reasoning that in their proposals are always deficient)

4.2.3.1.4.2 Corrective 40%

When doing their homework, doing experiments, playing instruments they want immediate feedback, and correct themselves accordingly.

- "Helps me doing experiments, warns me if I do something wrong"
- "An animation of explosion appears on the screen, when I answer incorrectly."

- “Sometimes when I study on my own at home, I learn things wrongly; a program may help me in learning correctly by giving me immediate feedback.”

4.2.3.1.5 Protective 57%

The qualities under the Protective group are designed to protect and enhance wellbeing of the children. Although those are not frequent concerns, they are worth to mention.

4.2.3.1.5.1 Preventive 30%

There are different properties designed to be preventive. They designed features aimed for prevention from accidents that may happen during experiments, prevention from improper internet sites etc. some of the respondents also designed their product without any harmful side effects.

- Nano-technological school uniform that protects child from chemicals
- Virtual laboratory equipments for experiments (preventing from lab accidents)
- Energy field mask that prevents face during playing basketball.
- The screen of the product doesn’t emit any radiation that is harmful for the eyes/ or have protective filter on it.

Furthermore, while they designed their idealized technologies, some safety issues arose, so they also designed additional features to overcome these problems. For example, if a respondent designed an individual computer, but it is not personal and used by every student, an account system for each student that protects the homework etc. with passwords is also designed.

- Personal account system protected by passwords in public individual computers.
- Locker that stores computers, can be locked to prevent theft

4.2.3.1.5.2 Individual limitations 20%

Some of the children designed technologies that enhance their physiological skills. Some others designed properties to enhance the learning of their handicapped peers.

- Robotic hands that allows to play musical instruments better

- A tool that generates the shapes of writings or drawings to let visually impaired persons to perceive
- A computer screen that can adjust itself depending on the degree of myopia or hypermetropia of the user (releasing them from wearing glasses)

4.2.3.1.5.3 Preventing fear of humiliation 20%

Some of the children uttered that they are very reluctant about asking question in front of the whole class. They thought that, if they make a mistake, they feel humiliated. One of the respondents asserted that the teacher is very harsh on them when they ask, so all of his students avoid asking any questions. Those children designed their products accordingly; they designed properties to overcome the fear of humiliation;

- An indulgent robot teacher
- One to one instruction with virtual tutor
- A system that sent questions to personal computers and answers from personal computers to smart board, allowing the children to stay at their desks. (releasing them from stress of being in front of the peers)

4.2.3.1.6 Networked 37%

Children wanted properties that allows them communicate with their friends and teachers. They also indicated that they want to be informed about the projects of other students, events of other schools and other leisure activities. They want to stay in touch and up-to-date with such designs;

- Announcements and daily plans are sent to their e-mails in their laptops/PCs/tablets
- Chat programs between them and friends and/or teachers
- A program that informs about upcoming cultural events such as newly arrived movies

Children's expectations related with smartness of the educational technology is covered, next section will be dealing with expectations related to physical properties.

4.2.3.2 Expectations related to physical properties of the product

While designing their smart educational product, children also mentioned many physical properties. Most frequently, they indicated that a smart tool designed for children should be usable, and to enhance and contribute to the learning process it should be personal and effective. Besides, many of them designed mobile and ubiquitous technologies that allow them seamless education. Lastly few of the respondents touched upon the environmental outcomes and economical aspects of their designed product. Following sections will provide detailed information about those constructs.

4.2.3.2.1 Usable 77%

The properties that make the tool usable, grouped according to the ergonomic quality (traditional usability) aspect of usability defined by Hassenzahl (2000).

4.2.3.2.1.1 Ease of use 70%

Most of the children stated that "It should be something easy to use", and designed properties accordingly. Respondents' concerns about *ease of use* are mostly related with interface of their products.

- Touch screen interface with or without pen
- Voice recognition system, that allows controlling the system with voice
- Virtual keyboard that can be projected anywhere
- Some of the children also designed the shape and height of the product. (since they use their body language to relate, it is very hard to illustrate in here)

4.2.3.2.1.2 Contextual limitations 43%

Considering their current schools and classes, respondents complained about how crowded and noisy their classes are. In order to create an appropriate place for learning, they first tried to eliminate those environmental constraints. Moreover, handful of children designed properties to create laboratory medium, like absence of frictional force, those properties also included in this construct because they are aimed to eliminate the constraints of physical environment.

- Individual screens that show what smart board exhibits to let students who are sitting on the back rows too see what is on the board.
- Headphones to eliminate noise
- A smart glass that shows microscopic things like cells

4.2.3.2.1.3 Controllability 17%

As mentioned earlier, children designed properties which are not directly aimed to enhance learning process, but for other reasons like to have fun etc. Few of the children mentioned the need to control these properties.

- A system that allows game play only when the teacher turns it on.
- A system that doesn't allow students to use unrelated programs with the ongoing lesson (e.g. painting program cannot be opened during mathematics course)
- It is not allowed to use smart pen during the exams.

4.2.3.2.2 Personal 73%

22 of the 30 designs are personal tools. It was almost the first property they designed. Desktop PCs, laptops, tablets, handheld devices, cell phones and more specialized designs such as touch-screen smart desks, smart hologram generating machines etc. are among personal technologies designed by children. On the other hand, others who didn't envisaged a personal tool, designed collective technologies such as smart boards, projected virtual tutors and robots etc.

A personal technology offers many solutions to fulfill children's needs –in coherence with constructs mentioned earlier-. For example, to name some; respondents designed personal technologies in order to eliminate physical constraints like crowd and noise, fear of humiliation, carrying school stuff; to facilitate their note taking, access to many information sources and communication process etc.

4.2.3.2.2.1 Identification 17%

Personal construct wholly includes the *Identification* construct. Some of the respondents who designed a personal tool mentioned properties for personalizing their product. Such as,

- Setting preferred background, fonts, color themes etc.

- Product with preferred color
- Be able to install favorite music, movie etc.
- Be able to present his/her artwork via product

There is one respondent though, thinks just the reverse; having personalized individual products may cause chaos, “everyone should have exactly same computer” she said.

4.2.3.2.3 Mobile 57%

More than half of the children designed mobile technologies, they also designed properties that will free them from carrying and handing of homework, project etc. they designed virtual mobility to that paper stuff.

- 47% of the respondents designed a mobile technology like laptops, tablets, smart-pens, smart glasses, hologram machines etc.
- Others gave virtual mobility (carrying information with flash disks or send them electronically) to other school stuff like books, note books, papers, homework, assignments, announcements etc.
- Especially the ones, who designed individual but public computers that are fixed at school, also designed personal flash disks.

4.2.3.2.4 Sustainable 27%

Some of the respondents defended the importance of sustainability in their designs. They mention three aspects related to sustainability of their designed products.

4.2.3.2.4.1 Economy 17%

Considering the outcomes of using computers and similar technologies instead of traditional methods, they thought that both families and schools will profit economically. There will be no waste of books, notebooks, and even laboratory equipment; they’re all will be replaced with virtual ones. Since they eliminated the burden of buying books and other stuff for school each year, their solution is categorized as sustainable.

4.2.3.2.4.2 Environmentalism 13%

The solutions for designing environmental friendly technologies are not so different from economically friendly technologies. Respondents thought that virtual replacements of traditional school equipments will also diminish the waste of paper and other consumables.

4.2.3.2.4.3 Durability 7%

Although too few respondents stated that their technology should be durable, it is worth to mention due to its contribution to sustainability. To give an example, one of the respondents designed two individual computers merged in one desk, thinking that this will enhance their durability.

4.2.3.2.5 Ubiquitous 17%

Even thought fourteen respondents designed mobile technologies only five of them mentioned ubiquitous properties. Those respondents stated their need of being able to access any information anytime anywhere.

- Online instructions pop up in cell phones
- Mobile technology has access to databases of school, anytime anywhere
- The video and/or audio record of the courses that can be watched via cell phones.

4.2.3.3 Expectations related to methodology

Since children were asked to design an educational technology in the school context, inevitably they also contributed the methodology of given education.

4.2.3.3.1 Multimodal Instruction 90%

Children were very eager to change the way that they are taught. Instead of traditional blackboard instruction, they designed lessons and instructions that address multiple senses.

4.2.3.3.1.1 Visual learning 80%

Children believe that if the given instruction is supported by rich visuals, they understand the subject better, and visuals make the context easier to remember.

- Pictures and animations to visualize various subjects in science, geometry etc. classes
- Realistic short movies in history class

- Pictures of the foreign words to ease memorization in language education
- Videos of native speakers to practice foreign language

Besides, some of the respondents didn't contented with 2D images, animations or videos, and they designed tangible models, 3D movies or holograms.

- Virtual reality experience (one of the respondents actually designed a time machine) for historical events
- Relief maps to comprehend geographical surface qualities better
- Holograms of organs and organ systems etc. which allows the child to see details easily.

Off course, the visual construct also includes the auditory support (for example in videos or virtual reality), some of the children though, designed properties that utilize only aurally.

4.2.3.3.1.2 Kinesthetic 63%

Large percentage of children indicated that they don't want to be passive listeners. They want to actively involve the learning process, so they designed accordingly. For example, one of the children said that she wanted to do the experiments by herself, but because of the limited materials, she had to watch it when her teacher doing, and as a solution, she designed a virtual experiment set.

- Virtual experiment sets
- Virtual foreign language tutors, to practice language skills
- A medium for each student, in which students may cultivate various plants and watch their growth.

4.2.3.3.1.3 Aural Learning 17%

Minority of the children claimed that they are better listeners and designed technologies that support them only via sound. Designed properties allow children to repeat the given subject by listening previously recorded lessons or the song version of the lessons.

- Embedded recorder to record the lessons

- Music (lyrics are the subject matter to be taught) to listen with MP3 players. One of the children summarized; “I am very good at memorizing lyrics of songs, so it would be easy for me to remember the subject, if it was given as songs.”

4.2.3.3.2 Adaptive 47%

Some of the children complained that they cannot understand the subject during the lessons or just forget it; they designed adaptive properties to enhance their learning. Most of the complaining children designed individual technologies that repeat the instruction until the user understands it. They wanted to be instructed suitable to their level and /or to be able to adjust the pace of the instruction.

- A system that records the lesson, child can rewind and watch/listen again and again until s/he fully understands the topic.
- “Each user watches videos for English lesson individually, stops where s/he don’t know the meaning of a mentioned word”
- Foreign language practice program which allows adjusting the level and translates the words whenever child wants.

4.2.3.4 Expectations related to interaction

All the aforementioned constructs are revealed by the children as they were elaborating on their idealized products. However, in the case of interaction, if respondents didn’t mention how s/he interacts with the product, they are asked directly what sort of interaction they would prefer without mentioning any specific interaction style. Therefore, it would be statistically meaningless to include the preferred interaction styles along with other constructs; they will be covered as a different section. In addition, it is worth to mention that some children designed more than one product, or more than one interface style in a specific product, therefore the total number of preferred interfaces is more than thirty. Figure 4-3 illustrates the preferred interaction styles.

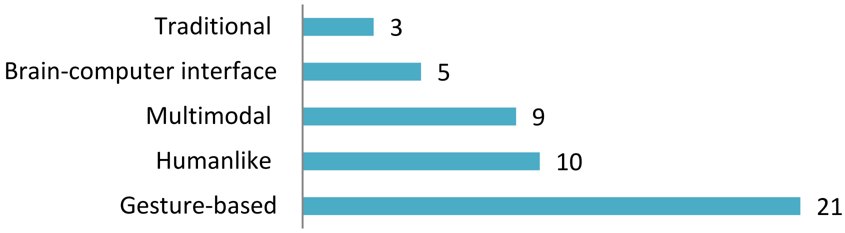


Figure 4-3 Frequencies of expected Interaction styles

4.2.3.4.1 Gesture-based Interaction

Most of the children preferred gesture-based interactions, majorly **2D gesture-based** interfaces. Half of the children designed touch-screens for their laptops, tablet PCs or handle-held products, reasoning that it is easy to use. Some of them indicate that they prefer touch-screen interface because it is the latest technology that is used in many products in the market. One respondent designed more creative interface which also basically a 2D gesture-based interface; a smart pen that projects a light keyboard to a surface, allowing the user to write down on.

Four respondents preferred 3D gestural interfaces. They designed 3D images, -in their words- “holograms” that can be manipulated with gestures, claiming that it would be easier to design and express what they imagined especially in their Science and Technology lesson.

4.2.3.4.2 Humanlike Interaction

Humanlike interaction, which is speech recognition and production, is the second most preferred interaction style. Children designed robots or personal tools that understand what child says and asks. Moreover, a young lady designed a voice recognition system to provide security in the use of public technologies. Again, the reason is ease of use.

4.2.3.4.3 Brain-computer Interface

Some children imagined a smart technology controlled via *brain signals* which can understand the thoughts and respond accordingly. For example, with the help of this interface, the smart product can comprehend the imagined product by reading child’s mind and project it; consequently it becomes easier to present more realistic projects done for their Technology and Design classes.

4.2.3.4.4 Traditional Interfaces

Least preferred interaction style is traditional interfaces; keyboard and mouse. Two respondents designed common table top or laptop PC used in school context. One other respondent embed keyboard and mouse as a bonus to his product which is normally controlled by brain signals. He explained that because keyboard and mouse are familiar interfaces, he can use them when the product fails to comprehend what he thinks. Hereby, he defined a multimodal interaction.

4.2.3.4.5 Multimodal Interaction

Nine of the children defined multimodal interaction. They combine the interfaces that are mentioned above; gesture-based, humanlike, brain-signal interface and traditional interfaces. To give an example; one of the respondent designed a handle-held product that understands voice commands also has the capability to project holograms.

4.2.4 Discussion

Children designed their dream products within the borders of their imagination. They are asked their expectations from a smart product that enhance their learning. Each designed property based on their expectations of future smart technologies and also based on their current needs. It is important to understand the level of significance among specified constructs to discuss the most and least valued needs and expectations in the view of children.

4.2.4.1 Order of significance among constructs

Z-score analysis is utilized to find out significant values. Table 4.2 shows the findings.

As illustrated in the table with bold borders, the constructs that have Z-score value more than 1, are considered to be significant, while the constructs that have Z-score value smaller than -1 are considered to be insignificant depending on 95% confidence interval.

Table 4-2 Frequency and Z-score values of constructs

Constructs	Groups	Frequency	Z-score
Substitutive	Smartness Property	24	1,85469
Visual Learning	Methodology	24	1,85469
Personal	Physical Property	22	1,54477
Ease of use	Physical Property	21	1,38981
Performative	Smartness Property	19	1,07989
Assistive	Smartness Property	19	1,07989
Kinesthetic Learning	Methodology	19	1,07989
Mobile	Physical Property	17	0,76996
Ease of access	Smartness Property	16	0,615
Ease of note taking	Smartness Property	15	0,46004
Fun	Smartness Property	15	0,46004
Novelty	Smartness Property	15	0,46004
Guidance	Smartness Property	14	0,30508
Adaptive	Methodology	14	0,30508
Ease of carrying	Smartness Property	13	0,15012
Contextual limitations	Physical Property	13	0,15012
Corrective	Smartness Property	12	-0,00484
Networked	Smartness Property	12	-0,00484
Preventive	Smartness Property	11	-0,1598
Aesthetically Pleasing	Smartness Property	8	-0,62469
Ease of calculation	Smartness Property	7	-0,77965
Visuality	Smartness Property	7	-0,77965
Preventing fear of humiliation	Smartness Property	6	-0,93461
Individual limitations	Smartness Property	6	-0,93461
Personification	Smartness Property	5	-1,08957
Controllability	Physical Property	5	-1,08957
Identification	Physical Property	5	-1,08957
Economy	Physical Property	5	-1,08957
Ubiquitous	Physical Property	5	-1,08957
Aural Learning	Methodology	5	-1,08957
Environmentalism	Physical Property	4	-1,24453
Durability	Physical Property	2	-1,55445

4.2.4.1.1 Insignificant constructs

Insignificant constructs are important to mention, because it may be crucial to understand why minority of the children suggest them.

As mentioned in the previous section properties underpinning ***aural learning*** are designed by the participants who claim that they are better listeners and believe that they can learn through music. Gardner's widely known multiple intelligence theory supports these claims. Some children may have strong musical intelligence, and the first thing they imagine to enhance their learning is music. Those children may be minority in this study, but considering that there are eight more intelligences, the percentage is somewhat meaningful.

All of the constructs that are under the sub-group *sustainable* (***economy, environmentalism, durability***) are found to be insignificant. This may be because, children focused on the properties that contribute their learning process since the major point of the interview was "a smart technology to improve learning process". The ones who mentioned *sustainable* properties might be affected from their immediate condition. For example, two respondents are siblings (6th grade male and 8th grade female) and both of them mentioned economical solutions in their designs (they eliminated the obligation to buy school consumables, books, notebooks etc.) and after they mention its contribution to environment; "besides it is also good for our environment". So, the economical concerns may be due to the socioeconomic status of the families (though affects of socioeconomic status is not investigated in this study, it is deduced because the two respondents are siblings).

The ***personification*** construct is mentioned by younger children (all of them are 6th graders). Those children designed considerate and sympathetic robot teachers or virtual tutors etc. One of the young girls claimed that she would be more eager to school if her tutor was a friendly robot. The frequency might be larger if all the respondents were 6th graders (33% of the respondents were 6th graders).

The effect of previous experiences is very obvious in constructs (corresponds with findings of Schmindt (2002). For example, the children who experienced safety issues such as theft or stealing of their works, designed properties that aimed to protect their stuff and homework. Therefore, majority of the children, who didn't experience such things, don't consider designing such properties. This might be the reason of small frequency of **controllability** construct. Very few of the respondents think that the features of the learning technology should be in control of the teacher to maintain discipline.

Very few children mentioned ***ubiquitous learning*** characteristics; this may be due to the nature of utilized method in this study. Children mentioned *explicit* needs in the interview; they might not be able to express *tacit* and *latent* needs (Sanders, 1992). Ubiquitous learning view is a new research area and almost none of the schools utilize this method yet (at least in Turkey). Therefore, the respondents were not familiar with it. It can be deduced that ubiquitous properties that are designed (such as mobile phones and other invented mobile technologies that provide anytime anywhere learning) are based on the respondents imagination.

One other least valued construct is, interestingly, ***identification***. Few of the children wanted their products to show off their personal preferences. This may be due to the focus of the study, “a smart technology to enhance learning”. If the children were asked to design a product not limited with education, the frequency of identification would probably be different.

4.2.4.1.2 Significant constructs

Children complained about shortcomings of school and their teachers. They add many properties to their designs to ***substitute*** these shortcomings and to receive more standardized education. Most of the schools either lack of many facilities or children are not allowed to use the existing ones. Therefore children find solution by designing virtual versions of the absent ones; for example, virtual experiment sets in the absence of lab materials, virtual chess in the absence of real chess. They even designed a 3D image producer which turns an empty field into any wanted sports field by projecting holographic images. They also designed virtual tutors to take place of their teacher claiming that, for example their teacher; talks unintelligible or cannot answer questions or cannot translate foreign words or don’t know how to play diverse musical instruments. Virtual tutor idea is reasonable when the primary concern is to standardize the given education because not all the children receive same teaching. On the other hand, the qualifications of teachers cannot be discussed in here, but it is better to keep in mind that sometimes children might be very harsh when judging their teachers.

Visual learning is directly related with methodology of the given course. More than 24 children expect that future smart technology presents visual materials, however, the reason behind their expectations are separated into two different needs. Some of the children wanted visuals to engage them (***visuality***), the other wanted because visuals help them learn and memorize easier (***visual learning***). Most of the children preferred visuals reasoning that s/he would understand the subject better. This is relevant with widely known Chinese proverb which is widely accepted by the educational society; *I hear and I forget, I see and I remember*. Results show that also children are aware of that.

Interestingly, ten children designed 3D models and holograms claiming that it further helps to comprehend details and remember. Since they have never experienced, for example manipulative holograms, this is not an expectation that is based on their previous experiences. One of the children shared where he got the idea; “there was a film, Star Wars, you can send yourself as a hologram…”

Actually, two of the respondents designed a time machine which allows them to go back in time and experience what happened in the history. It can be assumed as one further step of 2D and 3D visuals; they don’t want to be just listeners or viewers, they want to actively involve the learning process. This is another construct that is found significant; ***kinesthetic learning*** is also directly related to methodology. The respondents who mentioned properties related to *kinesthetic learning* construct, not only designed virtual reality systems, but also real mediums that inhabits smart systems to track what is going on in the biological environment in which each of the children cultivates their own plants and watches their development. This construct brings the sequel of the previously mentioned proverb; *I hear and I forget, I see and I remember, I do and I understand*.

Third most frequent construct is ***personal***, which refers to the expectation that there is at least one smart product for each child. Children explicitly express that they want to individually engage with the smart technology. That result may seem interesting while large percentage of educational society support cooperative learning. However, current methodologies utilized in the schools should be focused on, thanks to examination systems that each student face each year, children are taught in a very competitive environment. Children designed individual computers to relief themselves from that peer pressure in this competitive environment. Some children have *fear of humiliation* when they go to the blackboard and fail, those children designed remote personal answering systems to eliminate this probability. Respondents gave several other reasons for personal construct. Personal products allow children to show their personal preferences (*identification*). All the *adaptive* properties are designed for personal products to allow children repeat the given lesson as much as s/she wanted. Finally, all contemporary technologies are individual; PCs, laptops, tablets and mobile phones. One of the children said that they should keep up with the current technologies, so her technology should be personal.

Ease of use is another frequent construct. They defined many properties that make the product easy to use. Those properties are mainly about interaction. For example, majority of the children who designed touch-screen interface claimed that they prefer touch-screen because it is easy to use. In fact, only one child said “it should be something everyone can use” and didn’t specify an interaction. One other respondent defined ergonomic qualities such as height, shape and position of components (which affects use) of her product. The rest of them associated ease of use with interaction styles.

Performative construct refers to the properties that are designed to facilitate children’s job in many ways in the school context. Except the ones such as score counting smart goals, all of the performative features attributes to “laziness”. Children are very reluctant to do the duties they are not good at. For example, if a child cannot play the given instrument, he hates it. Hence, children designed robots or other intelligent products to do their job instead of them in such cases (e.g. a robot plays instruments instead of child). On the other side of the coin, children didn’t want to design anything for the classes they are successful. Therefore, performative properties are dream features of each child releasing them from mental or physical obligations they don’t like to do, and most likely they are based on children’s pure imagination.

Most of the children expect from smart technologies to be ***assistive***. They designed robots, handle-held products, smart phones and other devices to give them assistance, remind or suggest them what to do, help them to write and draw properly. While *performative* features do the child duty instead of him/her, *assistive* features help them to do their jobs better than they do on their own. Majority of the children are aware of the potential of technology. They are familiar with computers, software programs and their capabilities. Considering this, they designed similar programs to assist them. For example, some of the respondents imagined software very similar to Microsoft Paint or Adobe Photoshop to help them visualize their projects. Moreover, most of the children are aware of the activities that they have difficulty and designed features to overcome these difficulties. For example, a 6th grader complained about missing what his teacher tells when he is struggling to find the correct page for the lesson. He wanted his smart tablet to show the correct page swiftly.

4.2.4.2 Reasons behind the constructs & Grouping

Since the laddering technique is utilized during the interview, each expected quality has a reason. Children are asked why they wanted such feature, each time they designed new property. The sub-groups are constituted according to constructs common reasons. Table 4-3 summarizes the relations;

Table 4-3 Reasons/needs behind the constructs & Grouping

Constructs	Reason	Sub-Group	Groups
Substitutive	Enhance learning environment/tools		Smartness Property
Visual Learning	Enhance learning process	Multimodal Instruction	Methodology
Personal	Enhance learning environment/tools		Physical Property
Ease of use	Enhance learning environment/tools	Usable	Physical Property
Performative	Facilitate their jobs	Facilitative	Smartness Property
Assistive	Facilitate their jobs	Facilitative	Smartness Property
Kinesthetic Learning	Enhance learning process	Multimodal Instruction	Methodology
Mobile	Enhance learning environment/tools		Physical Property
Ease of access	Facilitate their jobs	Facilitative	Smartness Property
Ease of note taking	Facilitate their jobs	Facilitative	Smartness Property
Fun	Enhance learning process	Engaging	Smartness Property
Novelty	Enhance learning process	Engaging	Smartness Property

Table 4-3 (cont'd)

Guidance	Enhance learning process Facilitate their jobs	Directive	Smartness Property
Adaptive	Enhance learning process		Methodology
Ease of carrying	Facilitate their jobs	Facilitative	Smartness Property
Contextual limitations	Protect & enhance wellbeing/environment	Usable	Physical Property
Corrective	Enhance learning process	Directive	Smartness Property
Networked	Enhance learning process Enhance learning environment/tools		Smartness Property
Preventive	Protect & enhance wellbeing/environment	Protective	Smartness Property
Aesthetically Pleasing	Enhance learning process	Engaging	Smartness Property
Ease of calculation	Facilitate their jobs	Facilitative	Smartness Property
Visuality	Enhance learning process	Engaging	Smartness Property
Preventing fear of humiliation	Protect & enhance wellbeing/environment	Protective	Smartness Property
Individual limitations	Protect & enhance wellbeing/environment	Protective	Smartness Property
Personification	Enhance learning process	Engaging	Smartness Property
Controllability	Enhance learning environment/tools	Usable	Physical Property
Identification	Enhance learning environment/tools	Personal	Physical Property
Economy	Protect & enhance wellbeing/environment	Sustainable	Physical Property
Ubiquitous	Enhance learning environment/tools		Physical Property
Aural Learning	Enhance learning process	Multimodal Instruction	Methodology
Environmentalism	Protect & enhance wellbeing/environment	Sustainable	Physical Property
Durability	Protect & enhance wellbeing/environment	Sustainable	Physical Property

4.2.4.2.1 Subgroups of smartness properties

Facilitative

The constructs that facilitates children's job collected under this group. Children wanted to ease their duties (*note taking, accessing databases, communication,* *calculation, carrying school stuff*) in many ways as mentioned in the results section. Those designs are not unrealistic; they may be utilized even in today's technology easily. So, children may focus to learning process rather than engaging with time consuming activities. *Performative* construct is somewhat different from others, because it refers to the properties that children should do to learn, therefore it wouldn't be realistic to utilize.

Engaging

While children designed properties related to *fun*, *novelty*, *aesthetically pleasing*, *visuality* and *personification*, the main reason behind is to receive more engaging teaching. Because they expressed that they focus longer when there is something interesting going on. However, their effect may be temporary. It is a matter of debate, whether children are still be engaged when they get used to their novel technological tool, after for example two years of experience with that technology. All the fancy designs such as talking maps and wands, joking robots, flying schools etc. are novel and therefore engaging, but eventually their engaging potential may fade.

Directive

Both *corrective* and *guidance* constructs helps children to do their duties correctly. Sometimes children may learn something wrongly, when they study on their own. Therefore it is crucial to provide immediate feedback in tasks. Children told that they need guidance in their creative tasks; it is hard to come up with brilliant ideas without enough knowledge. According to them, databases harboring vast amounts of samples may guide them. However, this idea may conflict with the objectives of courses that aim to promote creative thinking. Because some children may tend to copy and paste the available works rather than force him/her to think creatively.

Protective

Protective sub-group includes constructs that are intended to protect wellbeing of the child; psychologically (*eliminating fear of humiliation*), physiologically and materially (*preventive, individual limitations*). Needs of the children related to those constructs are very basic needs and should have been already fulfilled even without technology.

4.2.4.2.2 Subgroups of physical properties

Usable

The constructs under the usable sub-group are; ease of use, contextual limitations and controllability. All of these to make the smart technology usable and learning process more efficient.

Sustainable

Sustainable sub-group refers to both economic sustainability and ecological sustainability. Children concerned about family budget stated economical benefits of their design. Besides, it is worth to mention that none of the children designed a property directly aimed for environmental (or ecological) sustainability. Environmental outcomes are mentioned as additional benefit. For example, children designed virtual books and notebooks to ease note taking and carrying and then mention “it also diminishes the paper waste”.

4.2.4.2.3 Subgroups of methodology

Multimodal Instruction

Different ways of instruction; visual, aural and kinesthetic are collected under this sub-group. The found learning modalities are in line with the perceptual styles mentioned in the study of Sun et al. (2003) (Section 3.2).

4.2.4.3 Relationship between interaction and constructs

Children are asked why they wanted the interaction style they designed. Table 4-4 summarizes the findings.

Table 4-4 Relationship between constructs and interaction styles

Interaction style	Related Constructs
Gesture-based	Ease of use Novelty Fun
Humanlike	Ease of use
Multimodal	Substitutive
Brain-computer interface	Ease of use
Traditional	Ease of use

Clearly, the main reason behind the preferred interaction is ease of use. Most of the respondents expressed that they don’t want to engage with complex interfaces, and don’t want to use extra devices (such as pen, mouse, keyboard etc.) to interact with the product.

Most frequent interaction styles are gesture-based and humanlike. Both styles are presents natural interaction. Because users can interact with products in a natural way, they also find this easy to use. Majority of the children preferred 2D gesture-based interfaces such as touch-screen. They are familiar with touch-screen, and be aware of how easy to use it. They also favor writing with “finger” in touch sensitive surface, eliminating extra devices like pen. More radical gesture-based interaction is 3D gesture-based, four children imagined to manipulate 3D images with their hands. Yet again, they didn’t mention an extra tool such as gloves. Presumably, although 2D gesture-based interface (touch-screen) preference based on their experiences, the 3D gesture-based interface based on the ideas they got from sci-fi movies. Some of them referred the movie which they got the idea from.

Secondly, most of the respondents who designed gesture-based interface think that interacting with gestures is fun. Lastly, few of the children designed gesture-based interface (specifically touch-screen) for novelty, claiming that this kind of interaction is utilize latest technology and their product should have the newest.

The ones, who especially have difficulty to represent what they imagine, designed interfaces that are controlled by brain signals. Without any effort, the product will be able to present and do what child imagined (particularly in Technology and Design course). Those children are eager to share that they imagine, but they think that they are not good at expressing that thoughts. Therefore, they propose telepathic interaction as a solution. Unfortunately, the research field of brain-computer interaction is in early steps and mainly focused on medical implications, scientists attempt to help disable and paralyzed patients (Hammock, 2010).

Multimodal interaction is preferred when the respondents are not sure their interaction will work in every situation, to compensate possible confusions, they designed an additional interaction style (touch-screen or traditional interface). For example, one of the respondents thought that, his brain signals may confuse when he writes down telepathically and at the same time listening to his teacher. As a solution he designed a touch-screen interface to correct mistakes. As well, the ones who designed humanlike interaction also embedded another interface, reasoning that their speech may interfere with each other.

4.3 CONCLUSION

In this empirical study, it is aimed to find out the expectations of children from smart technologies that will enhance their learning process. As a result, children expressed their needs in the school and learning context and they designed solutions according to their expectations. Interview with laddering technique is utilized to obtain a general data about the expected qualities and the reasons behind expectations.

Children's designed products harbor many properties based on their previous experiences and the ideas they get from various sources (movies, cartoons, books) and based on their difficulties and problems faced during their learning at school or at home. The findings of the empirical study are summarized and illustrated altogether in Figure 4-4.

In terms of **smartness**, children most frequently expressed that their smart product should facilitate their job, engage them to focus on learning and substitute the shortcomings of school and teachers. Prominent **physical properties** designed by children include usable, personal and mobile products. Children contributed not only to the product design but also the **methodology** of the given education; they want to receive multimodal instruction with rich visual sources and they prefer to actively involve their learning process. As well, nearly all of the respondents preferred **interactions** that are easy to use. Most expected interaction styles are natural interactions; gesture-based and humanlike.

In conclusion, if designers and educators take user satisfaction in consideration, the future learning technologies will be more personal, usable tools that facilitate students' job and motivate them by engaging qualities.

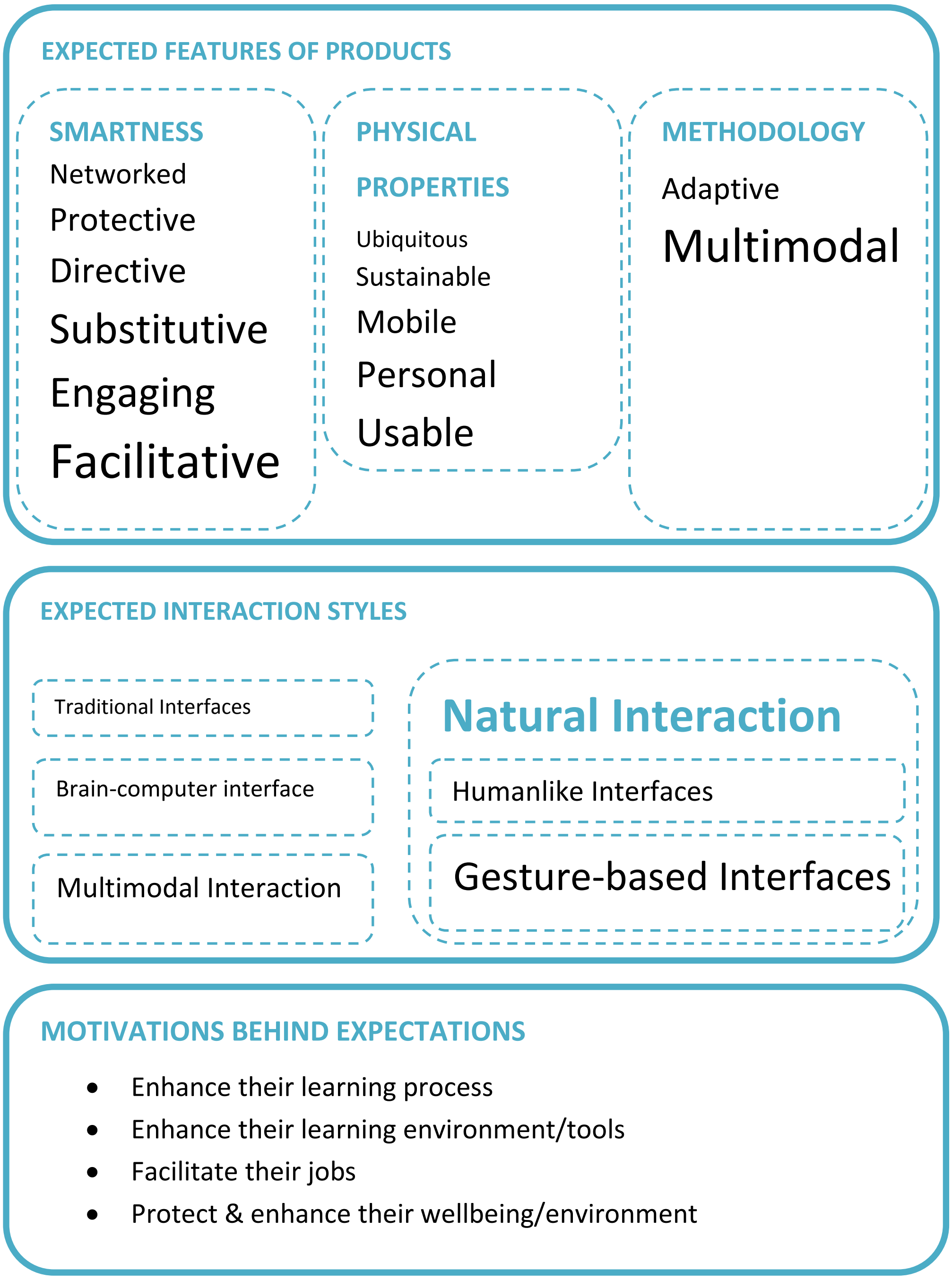


Figure 4-4 Findings of empirical study

CHAPTER 5

CONCLUSION

In this chapter, the study will be concluded with comparison of findings of literature review and empirical study. Figure 5-1 illustrates the findings as answers of the research questions given in the first chapter.

Table 5-1 Findings of each chapter

State-of-art Smart Products	State-of-art Learning technologies	Children's Expectations from Learning Technologies
Smartness Properties • **Context-aware** • **Reactive** • **Adaptive** • **Predictive** • **Communicate** • **Multifunction** • **Interactive** Physical Properties • **Mobile** • **Ubiquitous** • **Predictable** • **Controllable** • **Sustainable** Interaction styles • **Natural** o **Gesture-based** o **Humanlike** • **Multimodal**	Learning methodologies that utilize technology • **E-learning** • **M-learning** • **U-learning** With technology, learning becomes more; • **Adaptive** • **Personalized** • **Situated** (Mobile) • **Ubiquitous** • **Collaborative** (Networked) • **Learner-centered** • **Homogeneous** (Equal) • **Motivated** (Engaged) • **Facilitated** (Simplified)	Expected smartness properties • **Facilitative** • **Engaging** • **Substitutive** • **Directive** • **Protective** • **Networked** Expected physical properties • **Usable** • **Personal** • **Mobile** • **Sustainable** • **Ubiquitous** Expected methodology • **Multimodal instruction** • **Adaptive** Expected interaction styles • **Gesture-based interaction** • **Humanlike interaction** • **Multimodal interaction** • **Brain-computer interface** • **Traditional interfaces**

Limitations of the study and recommendations for future studies will also be mentioned in the following sections.

5.1 COHERENCE BETWEEN FINDINGS OF LITERATURE SURVEY AND EMPIRICAL STUDY

5.1.1 Smartness properties

Respondents' smartness expectations are partially consistent with smart products literature. Children defined interactive, multi-functioning and networked products as in the literature. However, none of them mentioned context-aware features. Adaptive and predictive behaviors of smart products described in literature, are capable to sense, learn and adapt to the users. However, none of the interviewees mentioned such behaviors; they only expect the product to adapt their learning styles with the input of the user, so it is directly related with received instruction rather than smartness of the product. That is why *adaptive* construct is mentioned under the methodology category.

On the other hand, most of the expectations are corresponded in the learning technology literature. With the help of technology, children wanted to facilitate their duties, receive more engaging and homogeneous (*substitutive* construct) teaching. Also, current learning technology is capable to satisfy the expectations related to *directive* construct; children may receive *immediate feedback* with learning technologies such as virtual training centers and *guidance* with online databases.

Respondents also designed *protective* features to maintain wellbeing of the user and his possessions. Although safety issues are not mentioned in the literature, there are products designed to *prevent fear of humiliation*; audio response systems or other personal products have potential to free children from the stress of peer pressure.

5.1.2 Physical properties

Respondents' expectations from physical properties of smart products are consistent with both smart product and learning technology literature. Children design usable products and environments for more efficient learning experience. Eliminating contextual limitations such as noise and crowd is one of the important dimensions of usable environment. Many products that are currently available such as audio amplification systems, document cameras and other personal products are capable of eliminating those limitations.

Three out of four children envisaged personal products consistent with literature. Both students and learning technology researchers are unanimous that learning should be personalized and adapted to the learner's perceptual styles. Besides, personal tools are necessary for other expectations to be fulfilled such as mobile, ubiquitous and customizable (*identification*) products. Likewise, more than half of the smart products designed as mobile to provide *ease of access, ease of carrying* and *ubiquitous* learning.

Sustainability issue is slightly referred both in interview and literature. While very few researchers think that a smart product should be sustainable, very few children touched upon the issue.

Ubiquitous construct is controversial among literature and interview. Although considerable amount of studies focused on ubiquitous computing and u-learning in literature, very small percentage of the respondents defined ubiquitous characteristics for their smart technology. This may be due to the fact that children are not familiar with such learning strategy. Likewise, according to some researchers in the smart product literature, a smart product should be predictable. However, none of the respondents mentioned any predictable behavior.

5.1.3 Methodology

The expectations that are more related with methodology of the given education than smartness or physical properties are collected under this group. As mentioned earlier, *adaptive* construct is related with *adaptive learning* rather than context-aware adaptive systems that are stated in the smart product literature. Therefore, consistent with learning technology literature, children wanted a learning technology that can be adapted to their level and learning styles.

They also designed multimodal instruction according to their learning styles; *visual, aural* and *kinesthetic*. Those learning styles are also in coherence with the perceptual styles mentioned in Section 3-2.

5.1.4 Interaction styles

Respondents' expectations related with interaction styles are very consistent with literature. Natural interaction styles are dominant in the smart product literature. Likewise, children preferred natural interaction mainly gesture-based and humanlike interaction. Few of the children preferred traditional interfaces such as keyboard and mouse or more creative interaction such as brain-computer interface. Also multimodality is another dimension mentioned in the literature. Consistently, some of the respondents designed more than one interaction style for their products.

In conclusion, findings of this study reveal that the expectations of children from learning technologies are substantially coherent with smart product and learning technology literature. Exceptions that are ubiquity, context-awareness and predictability can be attributed to the fact that children designed products based on their experiences and observations.

5.2 LIMITATIONS OF THE STUDY & RECOMMENDATIONS FOR FURTHER STUDIES

In this study, child as *informant* view is adopted and interview method is conducted to gather general view about the children's expectations from learning technologies. The nature of the utilized method is limited to obtain observable and explicit needs and expectations of the respondents; this is obvious in the case of ubiquitous construct. However, it is appropriate method for this study since the aim is to discover general perspective. Findings of the study can be used as initial ideas for conducting further studies. More generative methods can be conducted to discover latent and tacit needs and expectations of the children about the topic.

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APPENDIX

A - SAMPLE INTERVIEW IN TURKISH

The text of interview that was conducted with an 8th grade male respondent in Turkish is presented below.

Tasarımcılar artık çocuk olmadıkları için, çocukken olan sorunlarını, ihtiyaçlarını, zorlandıkları yerleri hatırlayamıyorlar. Bu sebeple, çocuklar için tasarlanmış iyi bir öğrenim teknolojisinin nasıl olması gerektiği konusunda sizlerin görüşlerini almaya karar verdik.

Nasıl bir teknolojik alet senin daha iyi öğrenmeni/ öğrenmeyi daha çok sevmeni sağlardı? Bir düşün bakalım. Hiçbir ekonomik ve teknolojik kısıtlama olmadığını farz ederek, istediğin kadar yaratıcı düşünebilirsin.

Aslında bu şeyler, herhalde bir filmde görmüştüm de, sanırım daha çok öyle bir şey. böyle her sıranın üstünde sıraya bağlı bir laptop, okulun kendisine ait.

Sıraya bağlı mı?

Evet bağlı, yani içinde. İşte hem ondan kendimiz yazardık, hatta şey bile olabilirdi hani böyle şimdi yani kanallarda falan çıkıyor bu, beyin gücüyle falan çalışan makineler var. Zihin gücümüzle falan orada yazılar yazabilirdik. Çok güzel olurdu, en azından elimiz falan yorulmazdı, hem dersi de daha aktif dinlerdik.

Anladım, yani bu alet otomatik olarak yazacak düşündüklerini. Neden böyle bir özellik tasarladın?

Bazı hocalarımız anlatırken bizim de yazmamızı istiyor, böyle bir özellikle yazarken daha rahat dinleyebilirsin. Ama bu sefer de başka sorunlar çıkabilir hocanın anlattıklarıyla kendi düşündüklerin karışabilir. Ama en azından her sırada bir laptop bile, her sırada kişiye özel, hoş olabilirdi.

Peki bu laptop, ya da zihninle kontrol ettiğin araç üzerinden gidecek olursak, başka hangi özellikleri olsun isterdin?

O bilgisayarın içinde programlar olabilirdi. Onlar sayesinde mesela kitap getirmeye gerek kalmazdı. Ona böyle yazardık, hem de okurduk. Kitap defter taşımak olmazdı, daha rahat olurdu. Böyle elimizi kolumuzu sallaya sallaya giderdik okula. O zaman okul daha çekici gelirdi öğrencilere.

Anladım, yani çanta taşımak istemiyorsun, bunu ortadan kaldıracak bir şey tasarlıyorsun. Peki tasarladığın şeyi biraz daha açabilir misin?
Bilgisayarın içinde konuyu anlatan kitaplar olacak. Hatta sesli videolarla konu anlatabilir, öğretmenin yanında ekstra bilgi verimli olur bize. O konuyla ilgili dikkatimizi çekici bilgiler falan olabilirdi. Değişik olurdu sonuçta.

Peki sesli video dedin, neden sesli video?
Şimdi öğretmenimiz bize hem görsel hem de işitsel olarak veriyor, şimdi orada da hem görme ve işitme olacak. Mesela oraya resim koyarlar, ilginç kısa filmler koyabilirler, dersi daha dikkat çekici, bizim de daha çok ilgilenmemizi sağlayabilir. Derse bir sevecenlik katar. Şimdi dersler ne? Öğretmen geliyor anlatıyor gidiyor. Bu rutin öğrencilere sıkıcı geliyor. En azından bu eğlence, renk katardı videolar falan.

Anladım ilgini çekmesini istiyorsun yani. Peki istersen şimdi derslerin üzerinde gidelim biraz. Mesela matematik dersi, dersin işleyişini düşündüğünde, bu tasarladığın araca ne gibi özellikler eklerdin?
Matematik dersinde işlem yapmak bazı öğrencilere zor geliyor, ben dahil olmak üzere. Bilgisayarda hesap makinesi falan da oluyor, kolay olurdu baya bir işimize yarardı. Üçgeni falan da anlatırdı. Yani burda öğretmen sadece yardımcı pozisyonunda olurdu artık, anlatıcı bilgisayar olurdu. Daha etkili bir eğitim sistemi olabilirdi bu bence.

Peki bilgisayar anlatırdı dedin, bunu biraz açar mısın?
Biraz uçuk kaçık olacak ama, bilgisayarın içinde konuşmasını sağlayacak bir hafıza ya da bir çip takılmış olabilirdi. Bu sayede bilgisayara verilen komutlar başka bir ana bilgisayara gönderilip oradan cevap gelebilir. Mesela bir şey yazarsın, bilgisayar sana anlayabileceğin şekilde anlatabilir.

Peki aynı konuları sana öğretmenin de anlatabilir, bunun yerine bir bilgisayarı tercih etmenin sebebi ne?

Çünkü bilgisayarla kişisel çalışıyorsun, ama öğretmenle tüm sınıfla. Ben mesela kendi adıma konuşuyorum, bazı konularda öğretmene danışmaya çekiniyorum. Çünkü hepsi farklı kişiliklerde, kimisi çok sevecen davranırken kimisi çok sert davranabiliyor. Yani bizim bir öğretmenimiz öyle mesela “nasıl anlamazsınız” falan diye bağırıyor, yerimize geri oturtuyor. İşte böyle bir bilgisayar sistemimiz olmuş olsaydı en azından öbür bilgisayarın ucundaki insan yardımcı olurdu bize. En azından tüm sınıfın ortasında “aa bilmiyormuş” durumuna düşmezdik, hem de öğrenmiş olurduk.

Anladım. Peki matematik dersi için eklemek istediğin bir şey var mı?
Matematik dersi için başka bir şey yok.

Peki o zaman sosyal bilgiler dersine geçelim.
Sosyal dersi bizde bu sene tarih dersi ağırlıklı, yapılan inkılaplar, savaşlar falan bilgisayarla görsel olarak gösterilebilirdi. Mesela o savaşı bir animasyon şeklinde veya slayt tarzı bir şeyle gösterilebilir.

Peki onun animasyon ya da slayt şeklinde olmasının ne faydası olurdu sana?
Şimdi mesela bazı insanlar, okuyarak ezberleyerek anlayamıyorlar. Onun yerine bir kitabı okuyarak anlayanlar vardır bir de aynı kitabın filmini izleyip de daha iyi anlayanlar vardır. Kitapta sadece okuma etkin oluyor, ama filmde hem görme hem işitme etkin olduğu için hem daha rahat hem de daha etkili oluyor. Bu savaşı falan görmüş olsak aklımızda daha iyi kalabilir. Mustafa Kemal oradan oraya gitmiş bunu görsek hem de eğlenceli olurdu.

Anladım daha eğlenceli olurdu, daha iyi anlardım diyorsun. Güzel bir fikir bence de. Eklemek istediğin başka bir şey var mı sosyal bilgiler dersi için?
Yani yok.

O zaman fen ve teknoloji dersine geçelim, derslerin işlenişini düşündüğünde ne gibi özellikler isterdin?
Fen dersinde mikroorganizmalar, DNA, mutasyon bunlarla ilgili bilgi vermesini isterim. Mesela öğretmenlerimiz “mutasyon” konusuyla ilgili 5-6 tane örnek verebilirken o bilgisayar bize istediğimiz kadar örnek verebilirdi. Hem belki bir taşınabilir belleğimiz falan olurdu, onunla o bilgileri alıp eve de götürürdük, hem okulda hem de evde çalışabilirdik böylece.

Anladım, yani okuldaki bilgileri eve de götürebilmek istiyorsun.

Evet, eve götürürsem evde de çalışırım, daha etkili olurdu.

Peki örnek dedin, bunu biraz açar mısın? Örnek derken soru örneğini mi kastettin yoksa farklı örneklerle konu anlatımı mı?

Soru örneği değil. Ya aslında dersine göre değişir, mesela matematik dersinde bir soruyu birkaç farklı yoldan çözmeyi gösterebilir.onun dışında mesela gene "mutasyon" konusunu farklı örnekler üzerinde giderek açıklayabilir. Mesel alt sınıflar için söylüyorum, kemik çeşitlerini falan, veya elementlerin hepsini böyle söyleyebilir bize nerede kullanıldığını tek tek açıklayabilir.

Yani sana bolca bilgi, örnek sunsun istiyorsun.

Evet.

Ama bunu sana hocan da sunabilir, ama sen bilgisayar sunsun istiyorsun, bunun sebebi ne?

Bazı hocalarında, bazı konularda anlamadığı takıldığı yerler olabiliyor. Şimdi bir de bizim hem dershane var hem okul, okulda hocanın anlattığı daha bir değişikken, dershanede anlattıkları daha değişik oluyor. En azında böyle bir sistem otursa dershane hocaları da okul hocaları da hazırlamış olsa hepsi aynı kapıya çıkar. Şimdi bizim okuldaki öğretmenler genelde yaşlı oldukları için formüllerle falan uzun uzun anlatıyorlar fen dersinde fen hocamız mesela. Dershanedeki hocamız kısa, pratik yöntemlerini gösteriyor. Bu bilgisayarlar da böyle pratiklerini gösterip dershane ile okulu birleştirip pekiştirebilirlerdi. Öyle daha iyi olurdu.

Hem dershane hem de okulun yöntemlerini içersin, birbirlerini tamamlasınlar istiyorsun öyle mi?

Evet.

Peki fen derslerinde deney yapıyor musunuz?

Hayır. Aslında deney yapmak çok eğlenceli olur, özellikle ben küçükken kimyager olmak istiyordum. Böyle değişik isimlerdeki maddeleri karıştırınca değişik şeyler oluyor. Ama biz yapmıyoruz ne yazık ki. Hocamız, laboratuvar olduğu halde oraya gidip kullanma gereksinimi duymuyor.

Anladım, peki imkanın olsa, yapmak ister miydin?

Tabii ki, kim istemez ki? Yani görerek anlamak çok daha iyi, mesela oksijen yanıcı maddelerden biri, yanma tepkimesine giriyor, hoca bunu getirirdi, her hafta giderdik, yapardık, çizerdik, not tutardık. Daha eğlenceli olurdu, daha iyi anlayabilirdik.

Anladım, deney konusunda heveslisin, peki bu teknolojik aletten nasıl faydalanırdın deney konusunda? Yani deneyleri düşündüğünde bu teknolojik alete eklemek istediğin başka özellikler geliyor mu aklına?

Deney için bütün aletlere sahip bir laboratuvar yeterli olur bence, teknolojik olarak bir şey aklıma gelmiyor.

Peki performans ödevleriniz oluyor sizin, mesela fen derslerindeki ödevlerini düşünebilirsin. bu performans ödevlerini başarabilmek için başka özellikler geliyor mu aklına?

Bizim okul otuz senelik bir okul, daha önceki öğrenciler tarafından yapılan performans ödevlerinin resimleri bilgileri falan olsaydı iyi olurdu. Biz işte bu performans ödevlerinden biraz ondan biraz bundan bakarak, kendimiz çok daha güzelini yapabilirdik.

Ben amacını tam olarak anlayamadım, biraz açabilir misin?

Amaç ilham almak, mesela bir öğrenci bir DNA modeli yapmış diyelim, ben mesela bunun daha gelişmişini daha güzelini nasıl yapabilirim diye düşünürüm. Ondan örnek alarak kendimiz daha iyilerini yapmaya çalışabiliriz.

Peki bunu istemenin sebebi ne, yani daha önce yapılmış işlere ulaşmanın sana ne faydası var?

Mesela bu performans ödevinde hocamız DNA modeli yapmamızı istedi, ben İnternette falan doğru düzgün yapılmış bir DNA modeli bulamadım. Yaparken de çok zorladım, 2-3 tane model hazırladım kendim sonradan da beğenmedim onları bir kenara ittim sonra tekrar yapmaya başladım. Yani uğraştırıyor, iyi ve yeni bir fikir pat diye ortaya çıkmıyor ki sonuçta. Bir de süreyi çok kısa veriyorlar. Bir haftada yapıp getirin diyorlar. Bir haftada o DNA modelini hem ayarlayacaksın, hem güzel görünecek hem de iyi not almanı sağlayacak. Bunu bir haftaya sığdırmak imkansız yani. Çok zor bir şey. Böyle bir şey olsaydı, bakardık, hem de kolay olurdu yapmamız ödevleri.

Oradan fikir almak istiyorsun anladığım kadarıyla.

Evet

Peki o zaman nasıl bir şey tasarladın, şimdi anlatabilir misin biraz? O ödevlere nasıl ulaşıyorsun? Mesela okulunuzda olan bir kütüphanede de olabilirdi bu ödevler, ama sen o tasarladığın teknolojik aletle ulaşmak istedin bu bilgilere, neden?

Dosya dosya kütüphaneye gidip onu aç, bunu aç araştırma yapmak yerine, böyle tüm bilgilerin toplandığı bir sayfa olsa, altında da bir arama butonu olsa yazınca bilgiler teker teker karşına gelebilir. Kütüphane biraz daha araştırma yapmaya dayanıyor ama herkesin araştırma yeteneği yok. Ben de dahil olmak üzere bazıları bakar bakar bulamaz, bazıları da o düzene alışıktır hemen gider bulur. Ama benim bu tasarladığım teknolojik alet, hem dersi eğlenceli hale getiriyor, hem de kolaylaştırıyor. Burada da dediğim gibi arama çubuğuna yazardık aradıklarımızı hemen de ulaşırdık,daha rahat daha kolay ve daha hızlı bilgi alırdık

Kolaylaştırmak istiyorsun yani. Anladım, güzel. Performans ödevleri ya da fen ve teknoloji dersi için eklemek istediğin bir şey var mı?

Yok, bu kadar.

Peki Türkçe dersi için özellikler eklemek ister miydin?

Türkçe dersinde bazı öğretmenler kitap okutturuyor. Bizim sınıfta da 3-5 tane öğrenci var, okumaları çok zayıf okuyamıyorlar. Şimdi hocamız da 6 tane kitap okumamızı istedi ve 3 hafta müddet verdi. Yetiştirebilen var yetiştiremeyen var. O bilgisayarda bunun için bir program geliştirilebilirdi, bize hikayeyi sesli olarak anlatırdı, biz de ona göre özet çıkartabilirdik.

Okumak yerine dinlemek istiyorsun, doğru mu anlamışım?

Evet dinlemek daha kolay. Oturacaksın, sayfayı çevir, gözlerin de ağrıyor, onun yerine yatağa uzanırsın gözlerini kapayıp direkt bilgisayardan dinlersin.

İyi fikirmiş, peki Türkçe dersini için başka eklemek istediğin bir özellik var mı?

Evet var, cümlenin öğelerini ayırıyorlar ya, işte bu bilgisayar da bize önce bir cümle verirdi. Küçük dokunmatik bir yeri de olurdu, küçük bir kalemiyle biz de istediğimiz yerini işaretlerdik. Oradan biz seçerdik bir düğmeyle, sonra bilgisayar da bize doğrulara doğru yanlışlara yanlış derdi.

Yani sana doğru ya da yanlış yaptığını direkt söylesin istiyorsun. Peki dikkatimi çekti, dokunmatik dedin, neden dokunmatik?
Günümüzün teknolojisinde dokunmatik daha uygun, dokunmatik telefonlar, masa üstü bilgisayarlar bile çıktı. Tuşlar artık eskide kaldı gibi bir şey oldu.

Yani sadece yeni bir teknoloji olduğu içi mi tercih ediyorsun yoksa, daha başka sebepleri varmı?
Daha yeni ve daha kolay, bir de eğlenceli de oluyor yani.

Peki İngilizce dersi için neler söylerdin? Yüz ifadene bakılırsa sevmiyorsun galiba.
Hiç sevmiyorum.

Aslında sevmediğin dersle ilgili daha çok tavsiyen olmalı. Fikir üretmen daha kolay değil mi? Mesela bir düşün bakalım nasıl özellikler o dersi sevmeni sağlardı? Bu teknolojik aletle ders nasıl işlenseydi severdin?
Mesela o alette çok güzel ve düzenli konu anlatımı olsaydı, anlamadıkça tekrar baştan, tekrar baştan dinlerdik anlayana kadar en azında uğraşırdık. O yönden iyi olurdu.
Onun dışında mesela İngilizce dersinden performans ödevleri veriliyordu, uzun uzun rüyalarımızı yazmamız isteniyordu. Biz önce Türkçe'sini yazıyoruz sonra çevirmeye çalışıyoruz. Ama bazı kelimelerin üçüncü hallerini falan bilmiyoruz, İnternette yazsak da bulamıyoruz, bu bilgisayarın içinde tüm kelimelerin ikinci ve üçüncü halleri olabilirdi. Onlara göre çevirip, daha etkin paragraflar yazabilirdik. İngilizceyi daha rahat anlayabilirdik.

İkinci ve üçüncü hal sözlüğü istiyorsun yani, peki başka fikrin var mı?
Benim yabancı dili algılamam zor oluyor, okurken anlıyorum ama duyarken anlamıyorum, gene sesli iki kişinin arasında geçen, anlayabileceğimiz düzeyde fazla ileri düzeylerde değil, hem alt yazılı hem İngilizce konuşma diyalogları olabilirdi, onu dinlerdik alttaki kelimelerle eşleştirirdik böylelikle hem telaffuzu kolaylaştırırdık, hem de kelimeleri öğrenmiş olurduk.

İngilizcenizi geliştiren bir program, güzel fikir, peki bunu bireysel olarak mı dinleyeceksin yoksa sınıfça mı?
Aslında bu bireysel olarak daha iyi, çünkü herkesin anlamadığı konu farklı olur, mesela biri *past tense*'i anlamazken biri *continuous tense*'i anlamaz. Böyle herkes tek tek

kendisi çalışırsa daha mantıklı olur. Çünkü dediğim gibi konuyu anlamış bir insanın bir daha bir daha aynı konuyu dinlemesinin ne mantığı var ki?

O zaman herkesin kendi gelişimine göre hitap etmesini istiyorsun.
Evet

Peki biraz da görsel sanatlar dersi için konuşalım, eklemek istediğin bir özellik olur muydu bu alete?
Öğretmenler bu sene bu derste böyle perspektif çizimler, natürmort, değişik çizimler yapmamızı istiyorlar. Bunun örneklerini çoğu kişi okula getirmeyi unutuyor. Ben mesela arkadaşlarım için fazla fazla götürüyorum. O bilgisayarlarda böyle konularla ilgili resim örnekleri olursa bizim de bir fikir kaynağımız olurdu. Mesela bize diyorlar ki konumuz uzaya gidişin 50.yılı. ben bununla ilgili ne çizebilirim ki? Bana bununla ilgili örnekler verse iyi olurdu.

Gene fikir almak istiyorsun yani.
Evet.

Görsel sanatlar dersiyle ilgili eklemek istediğin bir şey var mı?
Yok.

Peki müzik dersi için bir özellik tanımlar mıydın?
Müzik dersi bizim için pek etkili olmayan bir ders, hocamız bir hafta geliyor bir hafta gelmiyor, çok yapamıyoruz. Flüt çalabilenlere çaldırıp notunu veriyor, çalamayanlara parça okutturup notunu veriyor. O ders için yapılabilecek pek bir şey yok sanırım.
Yada belki şey olabilirdi, flüt çalmayı bilmeyenler için çalmayı öğretecek videolar olabilirdi. Her parçanın nasıl çalındığını gösteren videolar olabilirdi. Hem tonlamasını daha iyi yapardık flütte, şarkıda da söylemesini daha iyi yapabilirdik.

Tekrar sormuş olacağım bunu sana ama aynı şeyi öğretmeniniz de yapabilir, neden bilgisayardan izlemeyi tercih ettin?
Öğretmen konuyu anlatırken, öğretmeni hiç takmayan arkadaşlarımız var, bunlar arkada konuşurlar dersi dinlemezler. Ama mesela önümüzde bir bilgisayar olduğu zaman merak ederler bir açıp bakarlar en azından. Şimdi hoca orada anlatsa da anlatmasa da olur. Herkesin önünde kişisel bir bilgisayarı olunca yanındakiyle

konuşmaya fırsatı da olmazdı çünkü karşısında eğlendirecek bir alet var. Hem bilgisayarın içinde daha basit daha kolay anlatımı da olurdu, öğretmenden de daha etkin bilgisayar bence. Hem günümüzün teknolojisine de daha uygun. Eğlenceli olduğunu düşünüyorum, bu yüzden de ilgi çekici.

Sadece bilgisayar gibi bir teknolojinin olmasının dikkatinizi çekeceğini düşünüyorsun yani.

Evet, kesinlikle.

Peki beden eğitimi dersi ile ilgili bir fikrin olur muydu?

Sporlarla falan ilgili açıklamalar olurdu ama, kimse okumazdı gibi geliyor. Sadece bizim okulda da değil çoğu öğrenci topun peşinde koşturmayı seviyor beden derslerinde. Futbolun tarihi, nereden gelmiş diye mi bakacaklar, hiç sanmıyorum. Beden eğitimi ile bu sistem çok alakasız olurdu. Kullanılmazdı yani.

Peki o zaman. Teknoloji tasarım dersini düşündüğünde eklemek istediğin özellikler olur muydu?

Bu derste etkin olabilir çünkü neden; bu küp çizimi, silindir yapımı bunun gibi şeyler var. Bizim ilk ünitemizde küp nasıl çizilirdi, nereden kesme payı bırakılır, ölçüleri nasıl, detaylı nasıl çizilir falan gibi. İkinci ünitede proje yapıyoruz. Gene böyle proje örnekleri olabilirdi. Mesela bizden öncekilerin yaptığı projeler olabilirdi. Gene ilham kaynağı olarak, fikir almak için. Çünkü geçen sene bir ay kadar düşünmüştüm ne yapsam diye. Gelmeyince gelmiyor insanın aklına. Ben de o yüzden bu sene yazın düşünmeye başladım. Bu sene şimdi okulda direkt yaptım bitirdim, yıl sonuna kadar herkes bu ödevle uğraşıyor ama ben bitirdim, derste öyle oturuyorum. O sistem olsaydı, araştırma yapıp öğrenirdim, hem en azından boş oturmamış olurdum.

Peki araştırma yapıp öğrenirdim diyorsun ya, bunu biraz açsana nasıl yapardın bu tasarladığın aletle?

Bilgisayarın İnterneti olurdu. Aynı zamanda şimdi aklıma geldi, bilgisayarın yazıcısı olursa çok daha iyi olabilirdi. Okumanın yanında kısa kısa not not bilgisayarın hemen altından çıkabilirdi. Ne işe yarardı ona değineyim hemen. İster istemez unutuyor insan, notları hemen bilgisayardan çıkarıp sıranın kenarına, duvara falan yapıştırınca hatırlayabilirdik.

Peki görüntüsü şekli nasıl olurdu bu aletin biraz anlatmak ister misin?

Yarı tuşlu yarı dokunmatik bir şey olurdu. Ekran da dokunmatik olurdu, istediğimiz zaman ekrana yazardık istediğimiz zaman klavyeyi kullanırdık.

Peki neden iki seçenek koydun, dokunmatik daha iyi demiştin az önce?

Ama şimdi de şey aklıma geldi, bazıları dokunmatik kullanamıyorlar, tuşlu daha rahat gelenler var dokunmatik daha rahat gelenler var. Ben kendi açımdan düşündüğümde dokunmatik koydum. Ama diğerlerini düşündüğün zaman dokunmatiği gerçekten kullanamayanlar var, alışması da zor olabilir. Onun yerine hem tuş, hem dokunmatik daha iyi oludu. Belki de o gün canın tuşlarla yazmak ister, ya da amaan tuşlarla ne uğraşacağım dersin dokunmatikle yazarsın.

Peki okulda ders dışı faaliyetlerini düşündüğünde eklemek istediğin bir şey var mı? mesela kulüp toplantıları, sosyal etkinlikler, arkadaşların ya da öğretmeninle ilişkiler gibi.

Okulda bir ana bilgisayar olurdu önceden dediğim gibi o bilgisayardan bilgiler gelirdi. Ben mesela TEMA grubundayım, o grupta olmama rağmen çoğu toplantıdan haberim olmuyor. En azından o bilgisayardan e-posta halinde gönderilirdi, bizim de bu sayede haberimiz olurdu. Mesela okullarda duyurular için megafon oluyor, hoparlörlerden dolayı bazen duyamıyoruz, cızırtı oluyor, anlaşılmıyor. Burda mesela hemen yazı geliyor, tık okuyorsun.

İletişim olarak sadece okulla alakalı sınıflar arasında falan bir iletişim olabilirdi. Öğretmenin de bir bilgisayarı olurdu, ders başlayınca sohbeti kilitlerdi, kimse konuşamazdı. Dersten çıkarken açardı, teneffüste konuşurduk. Mesela alt sınıftan kişilerle konuşabilirdin, hatta kamerası olurdu, görüntülü de konuşurdun. Bazı insanlar dışarı çıkmayı yürümeyi sevmiyorlar, okulun dışı sınıflara göre çok daha soğuk olduğu için üşüyenler falan da oluyor, oturduğun yerden yemeğini, yer kolasını içer hem de arkadaşınla konuşurdun, iyi olurdu.

Peki güzel fikirler verdin, iyi bir araç tasarladın, sence en güzel, en vazgeçilmez özelliği hangisi oldu?

Dokunmatik olması ve bilgiyi eğlenceli ve aktif bir şekilde vermesi iyi özellikler oldu.

Bilgiyi aktif olarak vermesi dedin, onu biraz açar mısın?

Aklına ne takıldıysa o anda o bilgisayarı kullanarak onu bulabiliyorsunuz. Bu da bilgisayarın ne kadar hızlı ne kadar aktif olduğunu gösteriyor bize.

Bu son sorumdu. Çalışmaya katıldığın için çok teşekkür ederim. Eklemek istediğin bir şey var mı?
Bir şey değil. Yok, teşekkürler.

B - SAMPLE INTERVIEW IN ENGLISH

Below, the text of interview that was conducted with same 8th grade male respondent is presented in English. It is important to mention that since the answers of the respondent was very informal, it is impossible to achieve exact translation. Yet, the interview is translated meticulously to correctly present what respondent means.

Because the designers are no longer children, they don't easily remember their problems, needs and difficulties they faced during their childhood. For that reason, we decided to consult you about the features of a good learning technology designed for children.

What sort of a technological device would enhance your learning and make you like the learning? Think about it. As if there are no economical and technological limitations, you can be as much creative as you want.
Actually, I think I saw that one in a movie. There could be laptops attached to the desks of each student which were belong the school.

Is it attached to the desk?
Yes, I mean it is embedded to the desk. We could write on it, or it could even work with brain power. I saw this on a TV channel; there were machines that were controlled by brain power. We could be able to write on it with brain power. It would be great, at least my hands wouldn't get tired and also we could listen to the class more effectively.

I got it, so this device would write down your thoughts. Why did you design such property?

Some of the teachers want us to write down the subject while they are teaching, with such property you could listen better. But this time, there could be other problems. Teacher’s thoughts might interfere with your thoughts. But at least personal laptops attached to the desks would be great.

OK, considering this laptop or brain-power controlled device, what other features would you like to add?

There could be programs of books and notebooks in that computer. There would be no need to bring books to the school. We would read and write through those computer programs. So, we wouldn’t have to carry books and notebooks. School would be more attractive to the students.

I got it; you don’t want to carry stuff, so you design programs to eliminate this problem. Can you elaborate more on your design?

There would be books in the computer that teach subjects. Subjects could be taught with audio-visuals. An extra source other than teacher would be fruitful for us. It also could give us engaging information. Learning would be different.

Why do you prefer audio-visuals?

During the instruction, teachers present the subject both visually and aurally, in computer media the teaching should also be visual and aural. For example, if there would be pictures and interesting short films, the classes would be more engaging and we would be more motivated. Classes would be more lovable then today’s class where teacher comes, gives lecture and goes. This routine is very boring for students. At least audio-visuals would embellish the lessons.

So, you want to be motivated. OK, now we can go over the each lesson if you want to. For example, considering mathematics class, would you add other features to your product?

Some students, including me, have some difficulties with calculation. Calculator in the computer could be helpful.

It could teach geometrical shapes such as triangle. I mean, the teacher would be the helper; the computer would be the teacher. I think that could be a more effective educational system.

OK, you said that "computer teaches", can you elaborate on your idea?

It may be a crazy idea but, there could be a memory or a chip that lets the computer to speak. So, the instructions that are given to the computers are sent to the main computer, and answers come from main computer to our computers. For example, I write something, and the computer tells me in a way that I can understand.

Your teachers can also teach you the same subjects, why do you prefer a computer instead?

Because, studying with a computer is more personal while studying with teacher is a whole-class activity. I sometimes feel reluctant to consult my teacher because each one has different personalities. Some of them are friendly while others are harsh. For example, one of my teachers shouts us "how couldn't you understand" and makes us sit back without asking further questions. If we would have such a computer system, at least the person at the other computer (which is connected to the computer we use) would help us. At least we wouldn't be humiliated by peers as "uh he doesn't know" and we could also be able to learn.

I understood, do you want to add any other features for mathematics class?

No, there is nothing else for mathematics.

OK, let's move to social sciences lesson.

Social sciences lesson is mainly about history, revolutions and wars. Those issues could be presented visually. For example, wars could be presented with animations or slides.

Why do you prefer animations and slides?

Some people cannot understand with reading and memorizing. Some understand the subject by reading a book, others understand by watching a movie. In the case of books, only the reading is effective but for movies both seeing and hearing are effective, therefore movies are both easier to understand and more effective. If we would have seen a war (as a movie - instead of hearing about it from a teacher) it would stick in our minds better. If we would have seen the visits of Mustafa Kemal it would be more fun.

I understood, it would be more fun and you would understand better. I agree with you. Would you like to add other features to your design considering social sciences class?

No, that's all.

Let's talk about science and technology class, what other features would you design?

In the science and technology class, computer would present information about micro-organisms, DNA, mutation. For example, teachers only give 5-6 examples about mutation but computer would give as much example as we want. Also we might have flash disks that allow us to carry knowledge to home. So we could study both at school and at home.

So, you want to be able to carry knowledge that presented at school to home.

Yes, if I could be able to bring it to home, I would also study at home which would be more effective.

You talked about "examples", can you elaborate on that? Do you mean sample questions or an instruction with different examples?

Not sample questions. Actually, it depends on the class, for example, for mathematics it could show several different ways to solve a problem. Other than that, the topic "mutation" can be described by going through different examples. For junior classes, the topic could be types of bones or elements, it could tell us all, describe their usage areas in detail.

So you want to be presented lots of information and examples.

Yes.

Your teachers can also present you lots of information and examples. Why do you prefer computer instead of a teacher?

Some teachers may have difficulties at some topics. Also, we go both school and *dershane (dershane* is a private after school program which is not compulsory); the instruction at *dershane* is different from the instruction a school. If such a system was utilized both given instructions at school and at *dershane* would end up in the same media (computer). Because our teachers at school are old, for instance my science and technology teacher, they spend long times to explain the formulas. Instead, teachers in dershane present short and practical methods. This computer could also present practical methods and unify the methods of *dershane* and school teachers. That would be better.

So you want the computer to present methodologies of both school and *dershane* teachers to complement each other.

Yes.

Do you conduct experiments during the science and technology classes?

No, but it would be so much fun if we did. I wanted to be a chemist when I was younger. Different things happen when you mix differently named materials. Unfortunately we don't conduct experiments. Our teacher never uses the laboratory even though we have one at school.

I understood, if you would have the opportunity, would you conduct experiments?

Of course I would, who wouldn't? It is way better to understand the subject by seeing. For example, oxygen is a flammable material, it goes under combustion reaction. Teacher may bring that, we would go to laboratory every week, we do, draw, take notes. It would be more fun and we would understand better.

You are very eager about experiments. How would you make use of your technological product in terms of experiments? I mean, would you add other properties to your design considering experiments?

For conducting an experiment, all you need is a laboratory with necessary equipment. I don't think of any technological features.

OK, teachers assign you *performance tasks,* for example you can consider the one that given in science technology class. Would you add other properties to achieve these tasks?

My school is thirty-year school, it would be great if we had access to pictures and information of previous performance tasks that were done by former students. We could skim several performance tasks and do a better one for ourselves.

I couldn't understand your purpose, can you explain more?

My purpose is to draw inspiration. For example, let's say a student made a DNA model, I could look his work and think about how I can make better and more advanced model. We could take his work as an example and try to make better ones.

But why do you want this? What is the benefit of accessing the previous works?

For instance, for this semester's performance task, our teacher asked us to build a DNA model. I couldn't find any proper DNA model in internet. I also had difficulties during building. I prepared and disposed two or three models believing that they are not good enough and I started over again. I mean it is challenging. It is very hard to come up with a good and new idea. Also the time given to prepare performance tasks is very limited. They want us to do it in one week. In one week, you need to decide on and build a model that looks good and makes you to receive high marks. It is impossible to comply with that time schedule. It is very hard. If we have that it would be easier for us to do performance tasks.

So, as far as I understand, you want to get the idea from there.

Yes.

OK then, can you describe your design more? How do you access those performance tasks? For example, all those tasks could be collected in a library in your school, but you preferred a computer to access them, why?

Instead of a library that you have to open several files until you find what you want, there could be a page that all the information is collected. There could be a search button in which you write and information comes one by one to the screen. Not everybody has the ability to search, not everyone benefit from library efficiently. Including me, some people look for it but cannot be able to find while others who used to the system of the library, can easily find. Bu the technological device I designed, not only makes the learning fun, but also easy. As I said before, we would write on *search bar* what we try to find, and we get the information easily and swiftly.

So, you want to ease the process. Good point. Are there any other things that you want to add for performance tasks or science and technology class?

No, that's all.

What about Turkish lesson, would you like to add other properties for that lesson?
Some teachers make us to read books. There are 3-5 students in our class who cannot read properly. Our teacher asked us to read six books in three weeks. Not all of us can manage to do it. Computer could have a program that reads the book aloud, so we listen and then summarize the book after listening.

So you prefer listening a narrator instead of reading the book, is that true?
Yes, it is easier to listen. You have to sit down and flip the pages and your eyes may hurt while reading. But instead, you could lie to your bed and listen to your computer.

Good idea, any other features for Turkish lesson?
Yes, there is. Computer would have a program that gives us a sentence, and we would separate its elements. The computer would have a little touch-screen surface, and we would point anywhere we want with its little pen. Then, the computer would inform us which one is correct, which one is wrong.

So, you want to be informed about what is wrong or right. OK, you mentioned touch-screen, why do you prefer touch-screen?
Touch-screen is more appropriate in today's technology. Telephones, even personal computers are touch-screen. Keyboards are like old-fashioned.

Do you prefer touch-screen only because it is a novel technology? Or are there other reasons?
Newer and easier and also more fun.

OK, what would you say about English lesson? Considering your facial expression, I believe you don't like that course that much.
I don't like at all.

Actually, you must have many things to say about a course you dislike. Isn't it easier to imagine properties that make you like the course?
If the device would present good and organized English lectures, we could listen to it again and again, until we understood the subject. It would be better that way.

Other than that, we are assigned to write down our dreams in English as performance tasks in English classes. Firstly, we write it in Turkish and then try to translate to

English. But we don’t know the second and third versions of some verbs. We couldn’t be able to find them on internet most of the time. This computer might present us second and third versions of verbs. We could make use of them and create more effective paragraphs. We could understand English better.

So, you want to have a dictionary of second and third versions of the verbs. OK, do you have any other ideas related to English classes?

I have difficulty in perceiving foreign language; I understand it while reading but don’t understand while listening. Dialogues that are appropriate to our level could be presented. Subtitles could also be presented along with dialogues, allowing us match the speaking and writing. Therefore, not only we would understand the pronunciation but also learn new words.

It is a good idea. Is it a personal practice or whole-class activity?

Actually, it would be better if it were a personal activity because everyone experience difficulties at different points. For example, one could have difficulty in *past tense* while the other has difficulty in *continuous tense*. It would make more sense if everyone studies by themselves.

So you want the computer to adapt the instruction to level of each student.

Yes.

OK, let’s talk about visual arts class. Can you imagine any other properties?

This year teachers want us to draw perspective, still life, and some other different drawings. Most of the students forget to bring objects to draw. Sometimes I bring extra objects for my friends. If that computer would present sample pictures, we would have a source for composition ideas. For example teacher wants us to draw a picture about 50th anniversary of space expedition. What could I possibly draw about that topic? It would be better if we were presented with several pictures or photographs.

So, again, you want to get inspiration.

Yes.

Would you like to add any other properties for visual arts lesson?

No.

OK, would you like to add different properties for music classes?

Music classes are not effective classes for us. Our teacher doesn't show up in some weeks, and we don't do anything in those weeks. He gives marks by making students play flute or sing a song. There is not much thing to do for that class.

Or maybe computer could present videos that show how to play flute, for those who cannot play. There can be videos that show how to play each song with flute. We could play and sing better.

Your teacher or any other teacher could also help you, why do you prefer computer to teach you?

There are some students who sit at the back rows, talk to each other and don't listen to the teacher. But if we would have a computer on our desks, even they would be curious and give their attention to the lecture. If everyone would have a computer personally, they wouldn't spend time to talk to each other because computer is fun.

Also, computer might provide lectures that are easy to understand, it would be more effective than teacher. It also more appropriate to contemporary technology. Moreover, it's fun, therefore engaging.

So, you think that such technology as computer is enough to engage you?

Yes, absolutely.

OK, would you like to share your ideas about physical education?

There could be information about sports but no one would read it, I suppose. Not only in our school, but also in many schools, most of the students like to play football or basketball during the physical education class. They wouldn't sit down and read about history of the football. This technology is unrelated with physical education class, it wouldn't be used.

OK, let's move to technology and design course. Can you think of any other features to add?

Technology would be very helpful in that class because we try to draw cubes, cylinders and such things. In the first unit of this class, we were introduced how to draw a proper cube in detail; measures, margins etc. We are asked to prepare a project in the second unit. Computer, again, could present us some project ideas. For example, it might present former projects, just to let us have inspiration. Last year, I couldn't decide what to do as a project, I thought about it for a month. Sometimes, you cannot find a good idea easily. So this year, I started to think about it during the summer vacation. When the school started, I finished my project before anyone did. So, since there is nothing left to do, I just sat down did nothing during rest of the year. If there would be such system, I would inquire instead of twiddling my thumbs.

OK, you just said that "I would inquire" can you explain that more? How would you inquire with that technology?

Computer would have Internet connection. Also, it would have a printer too. Other that just reading, we could have notes and print them right away. If we would stick those notes to walls and other places that we see constantly, they would help us to remember.

OK, what about the shape and the appearance of the tool, would you mind talking about it?

It would be something half-touch-screen half-keyboard. The screen would be touch-screen, and we would prefer to write down via touch-screen or keyboard whenever we wanted to.

Earlier, you mentioned that touch-screen is better, why did you offer two options now?

Something new came to my mind: some people cannot use touch-screen and more comfortable with keyboard, while others are more comfortable with touch-screen. Considering my own perspective I have added touch-screen. But when I think about others, there really are some people who cannot use touch-screen and it might also be difficult to get use to use it. It would be better to have both keyboard and touch-screen. Maybe one day you might want to use keypad to write or you might not want to deal with keys and write with touch-screen.

Would you like to add any other properties considering extracurricular activities such as club meetings, social activities and communication with friends and teachers?

There would be a main computer at school and information came from that computer as I previously mentioned. For example, even if I am a member of TEMA group I am not informed about most of the meetings. At least that computer would send us e-mails so that we could be informed. For example there are megaphones for announcements in schools but sometimes we cannot hear due to the speakers and we cannot understand, due to whiz. But with the help of computer, you receive a note and you read it right away.

In the case of communication, there could be an inter-class communication system which is just related to school. The teacher might have had a computer and he could lock it down so that no one can access to the chat during the lesson. He could unlock it back when he leaves the class so that we can talk during the break. For example you could chat with people from lower grades and you could even talk to them via camera. Some people do not like going out and walking around; because outside of the school is much colder than inside, some people might feel cold. It could be good to eat your food, drink your coke and talk with your friends while sitting down.

You have provided good ideas and you have designed a good tool. Which properties of the tool are the best and the most indispensable ones in your opinion?

The best properties are being touch-screen and giving information in an engaging and active manner

What do you mean by "giving information in an active manner"? Could you explain it a little bit?

You could find whatever you think of at that moment. That shows us how fast and how active the computer is.

That was my last question. Thank you very much for attending this interview. Would you like to add anything else?

You're welcome. No, thanks.