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Towards Economical E-Learning Educational Environments for Physically Challenged Students

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1. Introduction

The World Health Organization defines Disability as follows: "Disabilities is an umbrella term, covering impairments, activity limitations, and participation restrictions. Impairment is a problem in body function or structure; an activity limitation is a difficulty encountered by an individual in executing a task or action; while a participation restriction is a problem experienced by an individual in involvement in life situations. Thus disability is a complex phenomenon, reflecting an interaction between features of a person's body and features of the society in which he or she lives[1]." Disabilities could be natural or could happen due to accidents. Technology could be used to create new software/hardware tools to help the disabled to participate in a creative collaborative educational environment.

In this chapter, we introduce two economically feasible solutions to aid physically challenged young students. They want they do (TWTD) is a simple system to help young students with hand disabilities interact with computers using web-camera and set of markers. The solution has been tested in some local schools and the results are promising [9]. Section 3 will introduce more details about version 2 of TWTD.

Autistic Touchless Board (ATB) is a system to help autistic children interact with computers with their hands. The system teaches autistic kids basic math and skills by projecting the problems on any surface (walls could be used) and the students interact by pointing to the wall without the need for extra tools. Section 4 will introduce more details about the design of ATB.

The rest of the chapter will be organized as follows:

- Section 2 will include the frameworks used to develop the e-learning environments.
- Sections 3,4 will include the two main developed environments. Each one will include the following points:
    - Problem
    - Solution

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- • Technologies used
- • Assessments and possible extensions
- • Section 5 will conclude and provide directions for future research

2. Technologies adopted

In this section we will include the frameworks used to develop the main e-learning environments.

2.1 Touchless as an alternative

Touchless is an SDK that allows users to create and experience multi-touch applications. Touchless started as Mike Wasserman's college project at Columbia University. The main idea: to provide the same functionality of a multi-touch environment using cheap hardware and open-source software. All the user needs is a camera, which will track coloured markers defined by the user. Touchless is released free and open-source to the world under the Microsoft Public License (Ms-PL) on CodePlex [2]. Figure 1 is a snapshot of the major classes of the touchless SDK [2]. We modified the touchless SDK to support different types of disabilities. The details will be introduced in sections 3 and 4.
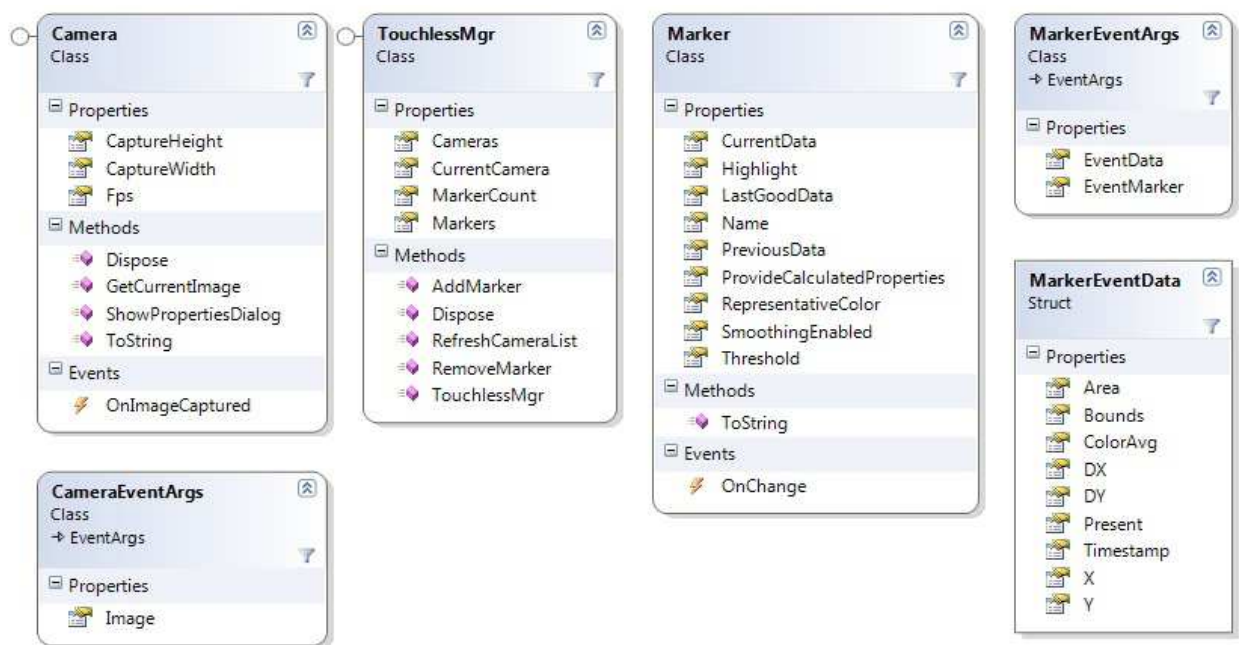
Fig. 1. Class diagram of touchless SDK [2].

2.2 Possible solutions

The following are some possible solutions to ease the interaction with computers for the physically impaired:

- • Software utilities that consolidate multiple or sequential keystrokes.
- • Mouth sticks, head sticks, or other pointing devices.
- • Trackballs or other input devices provide an alternative to a mouse.
- • Keyboard emulation with specialized switches that allow the use of scanning or Morse code input.

- Speech input and output.
- Word prediction software.

Our proposed solutions could be categorized as alternative to pointing devices.

3. TWTD

They want they do (TWTD) is educational software that uses markers and web-camera as a method of interacting with computers (to replace the mouse). The markers are defined according to the level of disability. The users then get educated using computers in different subjects. The aim of this solution is to help physically challenged students who were not able to use computers to get educated in a creative way. Also the solution is economically feasible since it only requires a web-cam and a layer of software for interactions. There are several products that target the same problem. TWTD (since it used touchless SDK) remains by far more economically feasible [9].

We implemented TWTD [9] as a proof of concept that creative solutions may help in educating physically challenged students with minimal resources. We already tried TWTD at special purposes schools in Kuwait to test the first version of the software. What we are presenting in this chapter is version 2 of TWTD.

3.1 Problem in details

TWTD was developed mainly for people who suffer different kinds of hand disabilities. After surving special needs schools in Kuwait, we identified the following problems:

- Students with hand disabilities are facing many difficulties to access computers.
- In Kuwait, there are many schools for the disabled. However, most students with hand disabilities are exempted from activities that involve computer usage.
- The only other option to dedicate teachers or helpers to help students use the computers.

3.2 Solution

We developed TWTD which is an economical educational tool with the following features:

- TWTD provides educational tools for Basic Mathematics, Science, Shapes, Colors and Basic English.
- TWTD adopts the curriculum of Ministry of Education in Kuwait
- TWTD is an educational software that uses markers and web-cam as a method of interacting with computers.

3.3 Use cases

Figure 2 depicts the main users of TWTD. Students can view tutorials and solve tests and exercises. Teachers can add and edit subjects, tutorials and exercises.

3.4 TWTD design

Figure 3 depicts the main layers of TWTD. In TWTD version 2, the databases were hosted on the cloud using Microsoft Azure cloud to accommodate larger databases and more subjects.

How touchless SDK was modified?

We modified touchless SDK to comply with hand disabilities. The original library has 3 markers. We customized the library to use two markers instead [9].
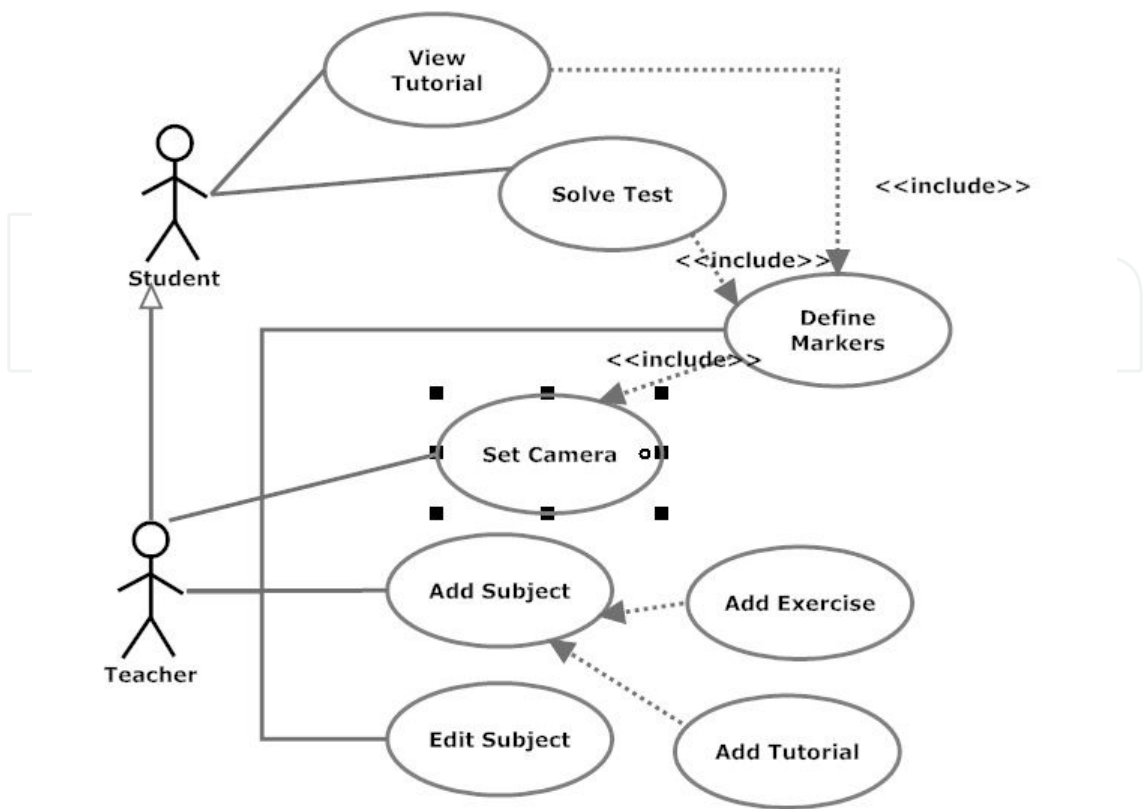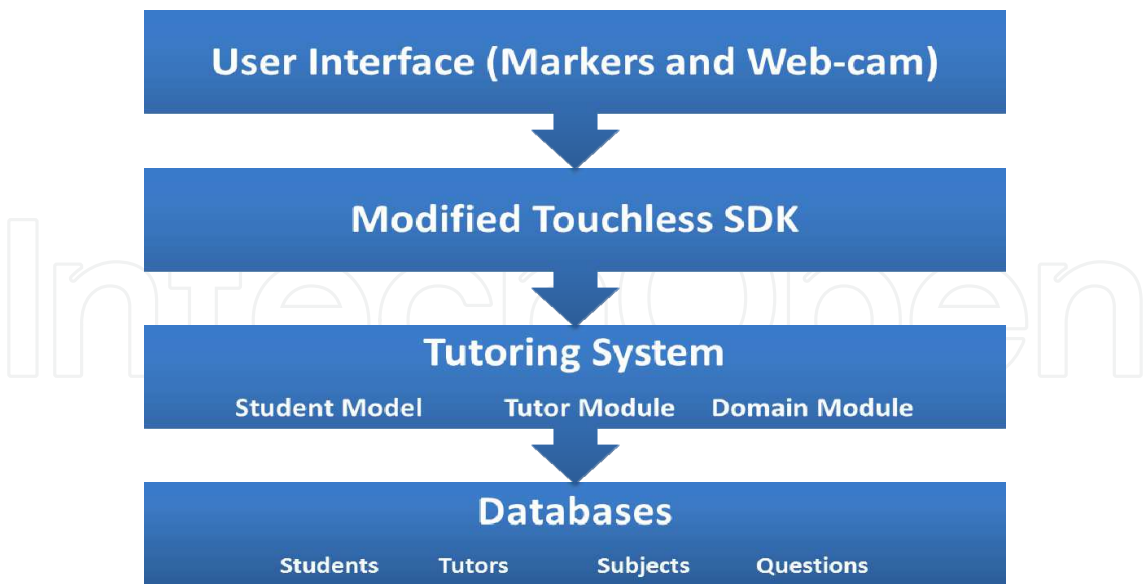
Fig. 2. Use Case Diagram for TWTD.

Fig. 3. Architecture Diagram of TWTD.

Figure 4 depicts the main classes of TWTD. The main classes are following PLITS [3] (a pattern language for constructing intelligent tutoring system). The details of using PLITS in developing TWTD are discussed in details in [9].
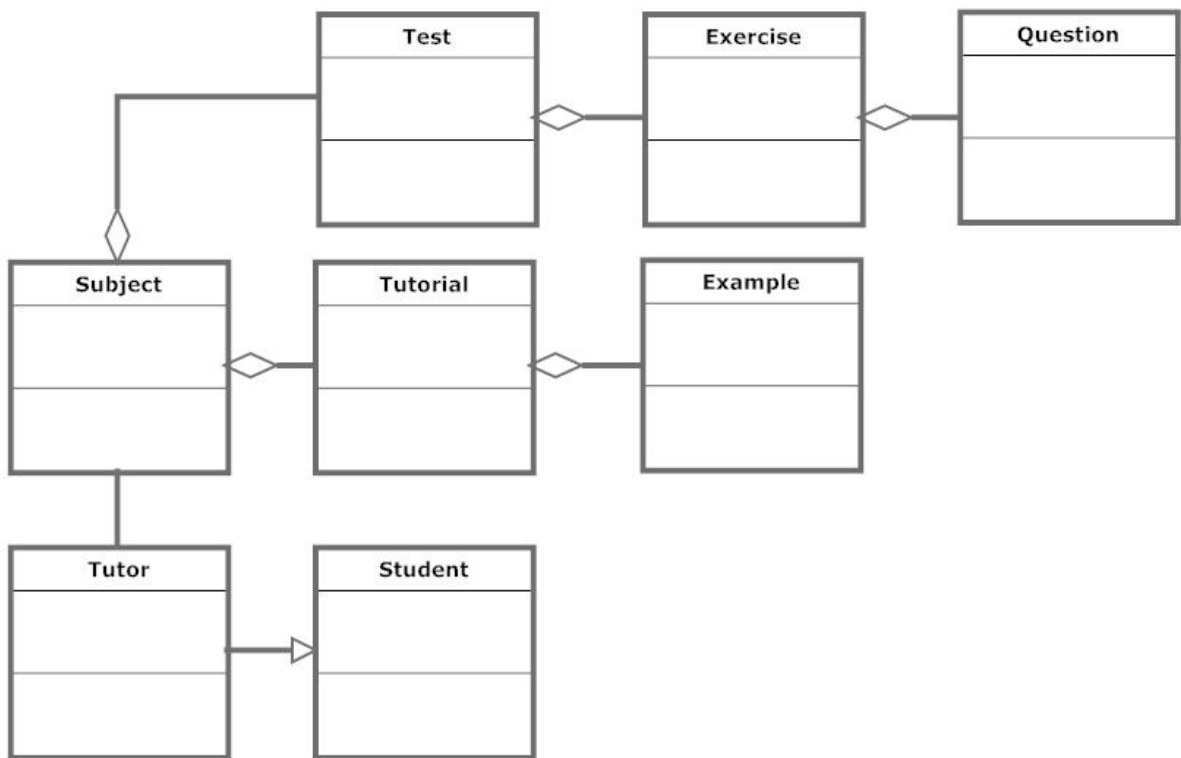
Fig. 4. Class Diagram of TWTD.

3.6 Using TWTD 2

Figure 5 depicts a snapshot of a handicapped student starting to use TWTD version 2. The markers are attached to the remains of the user's arms. In the figure the user is about to choose a given lesson out of the different options: English, Math, Shapes, Science). The applications are mainly what public schools offer in Kuwait.

Fig. 5. Setting up markers.

Figure 6 depicts a user interacting with the English application. In the upper right corner of the screen the user can see himself. The user can check his score at the end of the exercises. The figure also includes the Mathematics module where students have to match numbers to figures.

Fig. 6. Using TWTD.

3.7 Used technologies
TWTD was developed using the following technologies:
- Visual Studio 2008 Professional (Using the C# language)
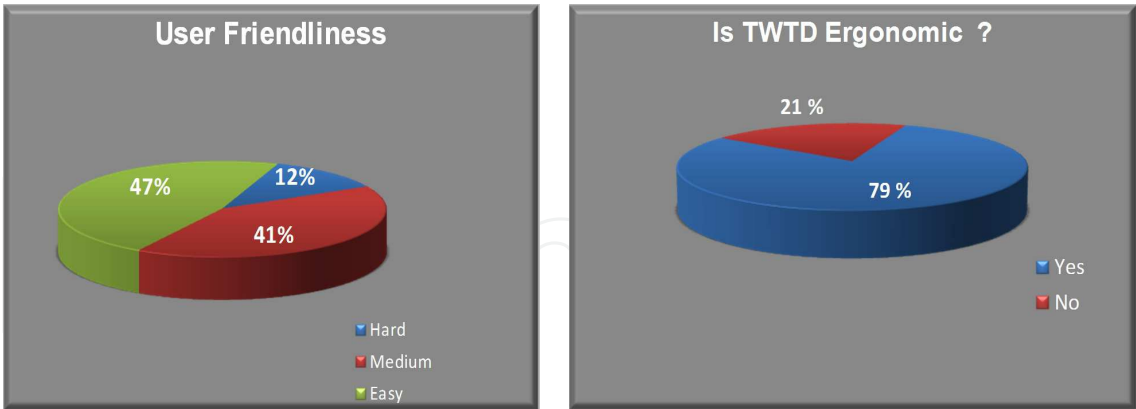- MS SQL
- Windows Azure

Fig. 7. Assessments of TWTD.

3.8 Assessments
Figure 7 depicts the results of the assessment experiments we carried out. The results of initial testing with 25 students show that 88% of the users indicated that using TWTD was east to medium. 79% confirmed that it is ergonomic.

Assistive technology has the potential to enhance the abilities and, bypass or compensate for barriers that disabilities make. TWTD addresses the potential of assistive technologies as it

relates to specific disabilities and life tasks. For children with disabilities in public school classrooms, assistive technologies are their tools to extend their physical, social and communicative abilities.

3.9 Similar work

While the total cost of TWTD does not exceed the price of the web-camera. Other similar products are far more expensive.

Microsoft surface

Microsoft Surface is a multi-touch computer that responds to natural hand gestures and real-world objects, helping people interact with digital content in a simple and intuitive way. Surface also sees and interacts with objects placed on the screen, allowing users to move information between devices like mobile phones or cameras. Although the product is not available for widespread purchase, it is relatively expensive.

HeadMouse Extreme

HeadMouse Extreme replaces the standard computer mouse for people who cannot use or have limited use of their hands when controlling a computer or augmentative communication device. The HeadMouse captures the movements of a user's head then translates it directly into proportional movements of the computer mouse pointer. This device works just like a computer mouse, with the mouse pointer being moved by the motion of the users head. This device cost around $1000 [6].

EyeTech TM2

The EyeTech TM2 replaces the standard computer mouse which allows the user with physical disability to place the mouse pointer anywhere on the screen by simply looking at the desired location.
EyeTech TM2 is program that uses a webcam set on the computer monitor that focused on one eye. EyeTech TM2 software Eye tracking is the process of measuring either the point of gaze or the motion of an eye relative to the head.Mouse clicks are done with either a slow eye blink, eye gaze or a Hardware switch (toe click, finger click, etc). The device costs around $6,500 [7].

Jouse 2

The Jouse2 is an advanced joystick-operated USB mouse that is controlled with user's mouth. The user moves the joystick with his/her mouth, cheek, chin or tongue to shift the mouse cursor wherever she/he wants. The further the user moves the joystick, the faster the cursor shifts. The user can perform right-click, left-click and double-click actions with the sip and puff switches built into the Jouse2. The device costs around $1500 [8].

4. ATB

4.1 Problem
Autism is defined by the Autism Society Of America (ASA) as: " a complex developmental disability that typically appears during the first three years of life and is the result of a neurological disorder that affects the normal functioning of the brain, impacting development in the areas of social interaction and communication skills. Both children and adults with autism typically show difficulties in verbal and non-verbal communication,

social interactions, and leisure or play activities. Also, children with such syndrome may harm themselves if they use new tools. According to teachers in the Autism center in Kuwait, a 13-year old autistic child swallowed 64 magnetic pieces while interacting with some lessons at the Autism center. It is not advised to have any tool around autistic children, which makes the educational process even harder.

Latest statistics show that about 1% of children is diagnosed with autism. An estimated 1.5 million individuals in the U.S. and tens of millions worldwide are affected by autism. Government statistics suggest that autism is increasing annually. There is not established explanation for this increase, although improved diagnosis and environmental influences are two reasons often considered. Other research efforts noted that males are more vulnerable than girls. Current estimates indicate that in the United States alone, about 1.5% of young males are diagnosed with autism[10].

Studies in the United States during the 1990s have estimated prevalence rates of autism to be 2.0-7.0 per 1,000 children, an over tenfold increase compared to the 1980s. This suggests that autism is being identified and diagnosed much more in the community in recent years [11].

Autistic children suffer in both social and educational activities, according to a new study in the journal Neurology. In a recent study children with mild autism was compared to normal children regarding how to form words from letters. It was found that autistic children faced difficulty in forming words [12].

Autism is considered to be one of the most difficult developmental disabilities in the world. Parents of autistic children have hard time understanding their child and helping them to learn. Autistic children can't use any tools in their learning process as they can easily hurt themselves. As a result, teaching Autistic children involves many risks and concerns about children's safety. The learning material for autistic children is limited due to these constraints. Therefore, we aimed to provide a solution that consists of a projector and camera to help them learn in a new, safe and interesting way whether they're at home or at school. The students do not interact with the projector and the camera, rather they use their fingers to interact with a projected image of the screen.

Technology could be used to help autistic children by providing economically feasible solutions. In this section, we design a solution for autistic children to help them learn in a safe, creative and economically feasible method.

4.2 Solution

ATB is a solution that helps Autistic children in their education process by enabling them to interact with the computer in a safe and secure way without using any tools. The child will be able to control computer applications through the projected screen on the wall using their fingertips only. In addition, we provide autistic children with educational applications that are designed to suit their educational needs. The applications teach basic math and matching.

4.3 Use cases

Users can interact with the system using the traditional mouse clicks events. The user can drag, click, switch between applications, open and close applications. The teacher could use the system similar to the child and also could do more by:

- Activating the system
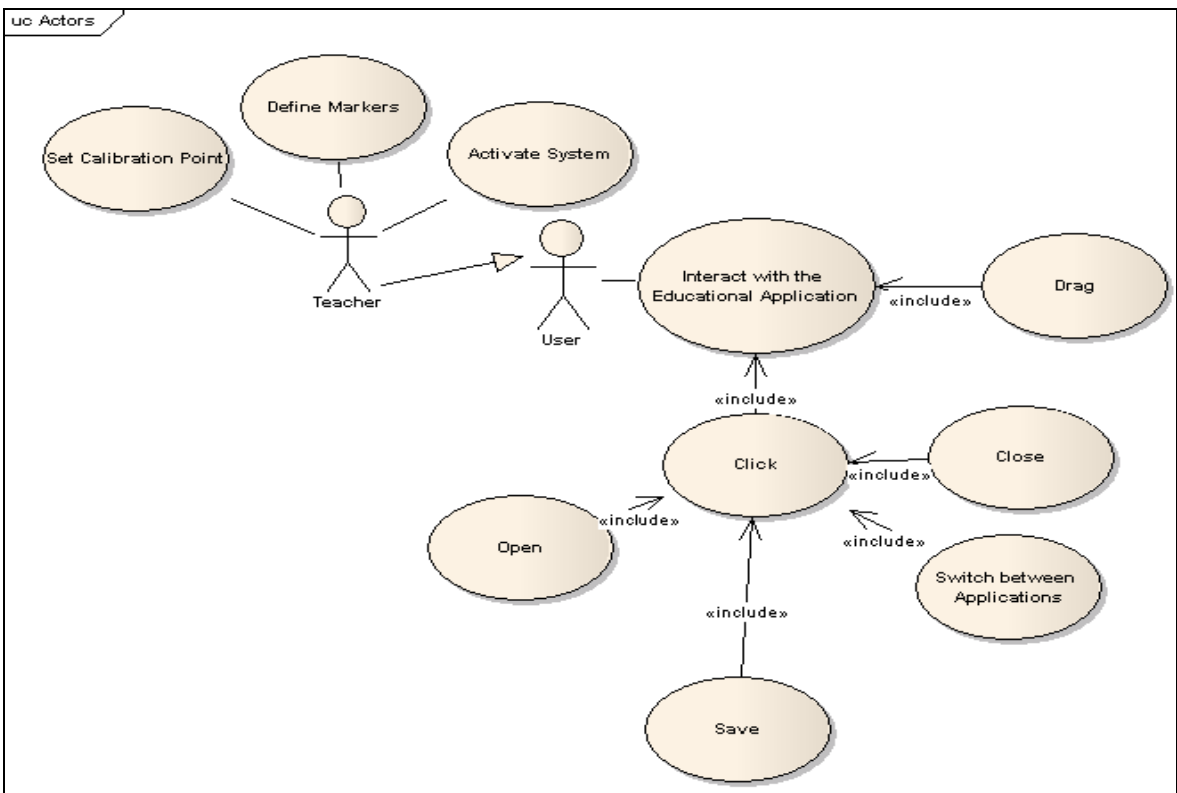- Defining markers
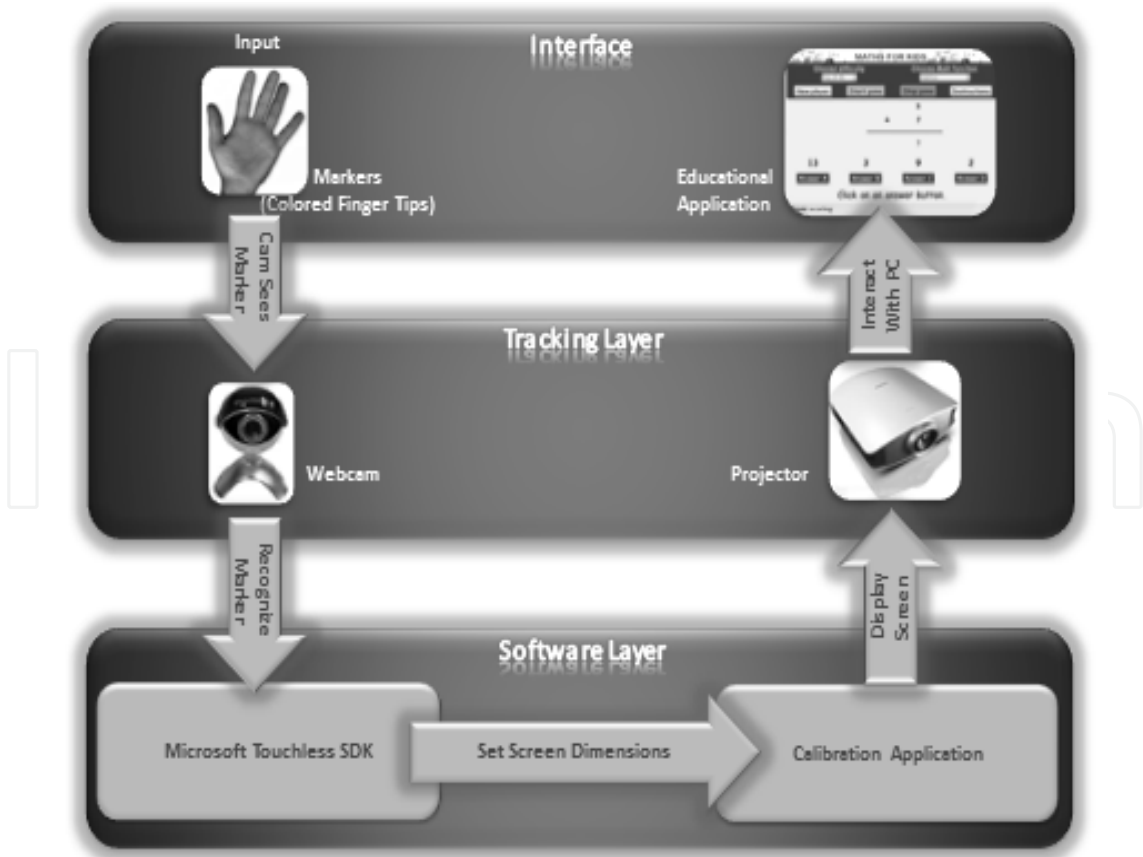- And Setting Calibration Points

Fig. 8. Use Cases of ATB.

Fig. 9. Architecutre Diagram of ATB.

4.4 ATB design

ATB mainly consists of three layers (Figure 9). The layers are: interface layer, tracking layer and software layer.

a.   Interface Layer

The interface Layer consists of the PC desktop or the educational application. The user shall interact directly with the PC through the hand gestures to form different marker events (i.e. click, drag…etc.)

b.   Tracking Layer

This layer is the middle layer. It consists of the projector and the webcam. It helps convert the whiteboard to an electronic touch-screen, where any program can be controlled through hand gestures. The webcam will track the hand gestures through detecting pre-defined colors.

c.   Software layer

This is the bottom layer, which consists of the Calibration Applications and Microsoft Touch-less SDK.

- Calibration Application: It is software to measure the dimension of the PC's screen and represent it on the whiteboard through the projector. The main idea is to calibrate the resolution of the pc screen to the dimensions of the white board.
- Modified Touchless SDK: In this application we modified the click action to accomodate the interaction method. The code was modified so that the click event is generated if the user holds his hands/markers over an object (on the wall or screen) for around 2 seconds. The advantage of this method is that it is fairly simple.

How Touchless was modified?

We added the calibration application to interact with touchless SDK for better performance. The main purpose is to calibrate the resolution of the screen and the virtual display. The application is mainly to improve the accuracy of the markers interactions.

Figure 10 depicts the main classes of ATB. The first set of Classes includes the following classes: ActivateSystem, Marker, and CalibrationPoints. In the ActivateSystem class, the user (teacher or admin) can startSystem and EndSystem. While in the Marker class, the teacher can DefineMarker or add NewMarker. Moreover, the teacher or admin can setCalibrationPoints in the class CalibrationPoints. However, the class CalibrationPoints is aggregated to the class Marker; that is, if the user didn't define a Marker, he or she can't setCalibrationPoints. Also, the class Marker is aggregated to the class ActivateSystem. The teacher can't defineMarker or add newMarker without Activating the system first.

The second set of Classes includes three classes which are: Subject, Lesson, and Test. In the Subject class the user (Autistic User) can chooseSubject or close the Application. While in the Lesson class the user can start NewLesson, OpenLesson (open a previous lesson), SaveLesson, and CloseLesson. In the Test class, the user can start NewTest, RepeatTest (repeat a previous test), and check the TestScore. Also, the class Test is aggregated to the class Lesson, and the class Lesson is aggregated to the class Subject. That is, the user can't take a test if there is no lesson, and the user can't take a lesson if there is no subject.

4.5 Using ATB

Figure 11 depicts the sequence diagram of calibration process. The user "StartSystem()" to start the ATB System. After that, the admin should select "defineMarker" to define a new Marker. After defining a Marker, the admin or the teacher should carefully set the

calibration points through selecting "SetCalibrationPoints()". This will set the dimensions of the whiteboard. Doing this process will convert the whiteboard to a smart interactive board. As a result, the user or the admin can interact with the whiteboard through hand gestures. So, he or she can run the Educational Applications to "chooseSubject()".
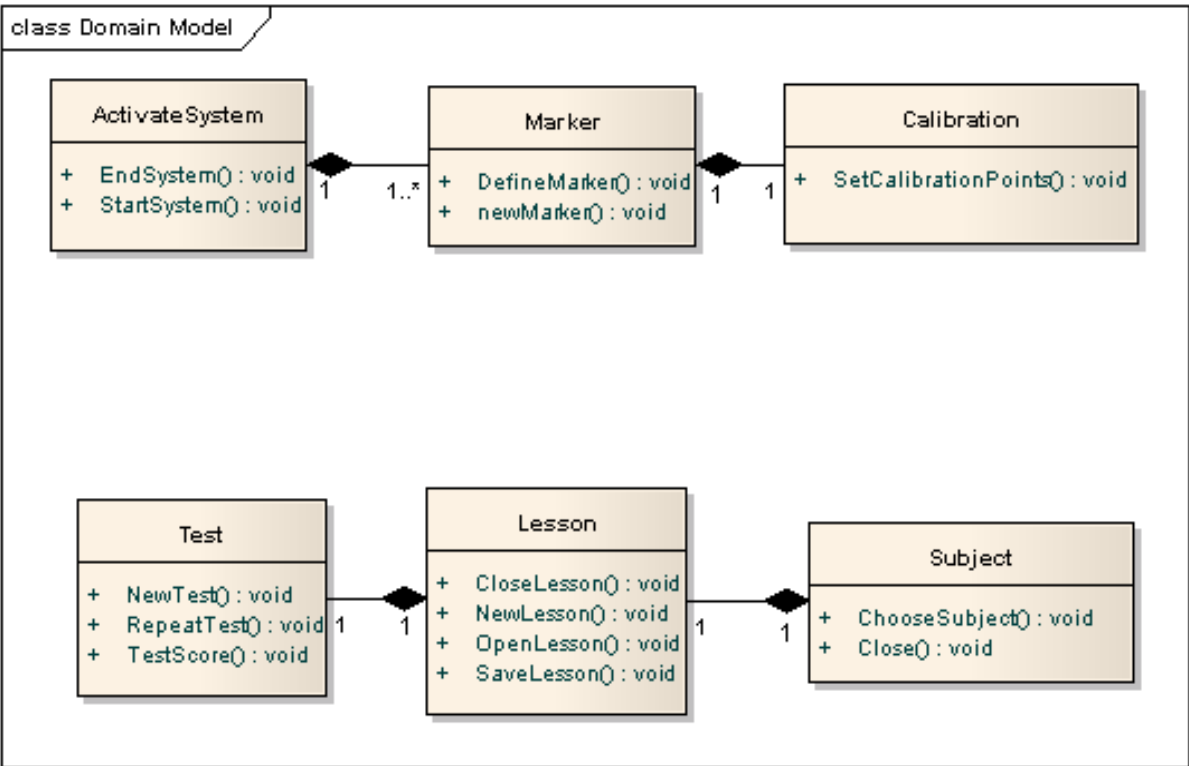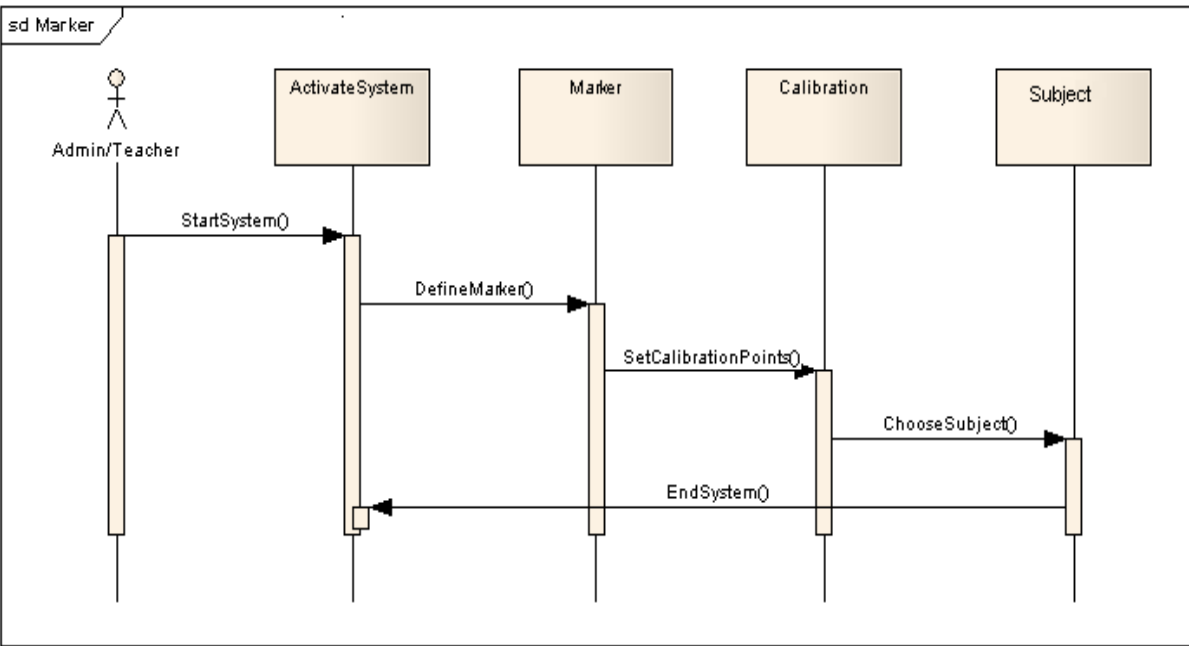

Fig. 10. Class diagram of ATB.

Fig. 11. Sequence Diagram of using ATB.

The educational programs

Figure 12 depicts user sequence diagram for user solving a question in a test. The user shall "ChooseSubject()" to choose between the Educational Applications (Math Application or the Voice Recognition Application). Then, the user can start a "NewLesson()" where he/she can learn new subject. After finishing the lesson, the user can "SaveLesson()" and "CloseLesson()". After learning the lesson, the user can start a "NewTest()" to test his/her abilities. Users can "RepeatTest()" to repeat previous test. If the user finishes the test, he or she can view "TestScore()" and end the Educational Applications through using "Close()".

The educational programs are html applications that are addressed to Autistic children age 8 to 10. There are two Math programs, one in Arabic and the other in English. The Math program allows the children to choose the difficulty of the math problems, and choose the math function: adding, subtracting, multiplying, random adding and subtracting, or random adding, subtracting and multiplying. This program keeps track of the scores the child achieved and his or her speed. Figure 13 shows a user using the mathematics lessons with her bare hands as a pointer.
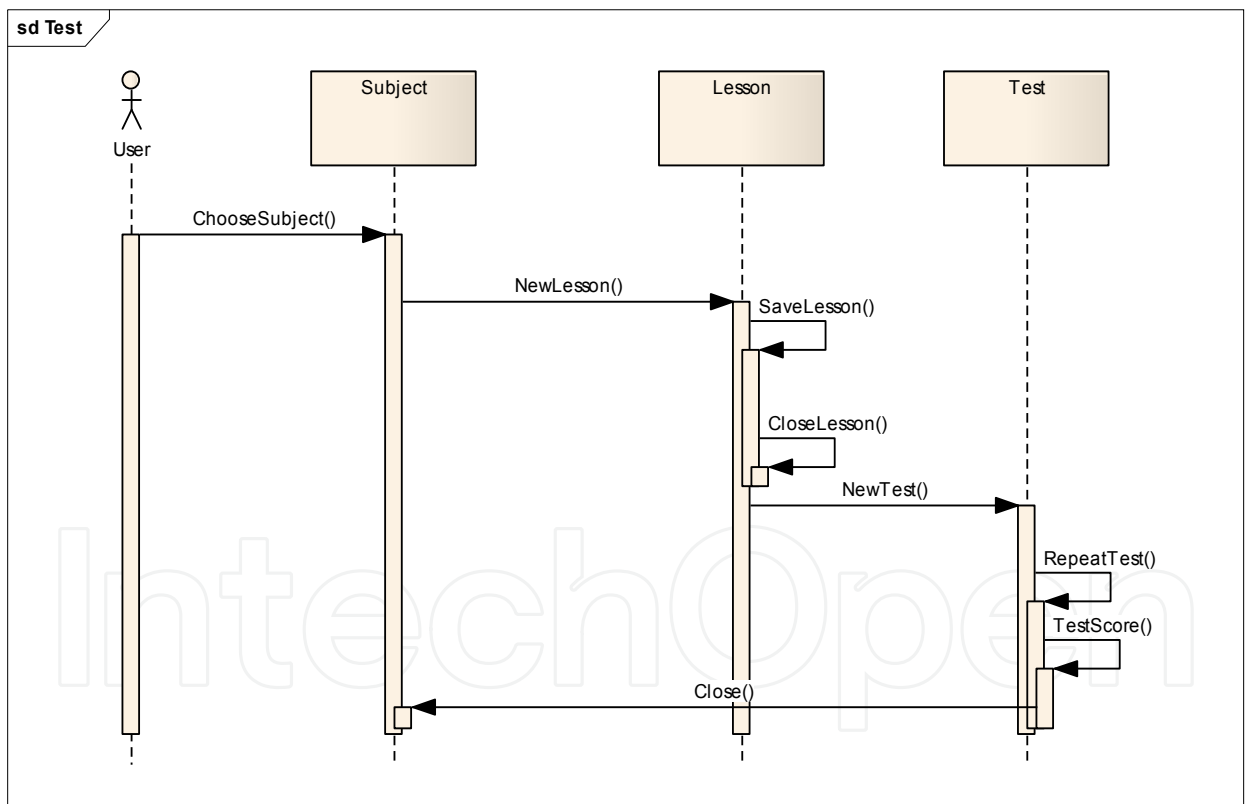

Fig. 12. Sequence Diagram for solving a question in a test.

In Figure 14 another educational application is shown, the child can see different animals' pictures and by pointing to the image they will hear the animal voice. In tests, the child will hear the animal voice, and will see different images of different animals. So, he will aim to choose the appropriate image. The scores and speed will be stored with the child's name.
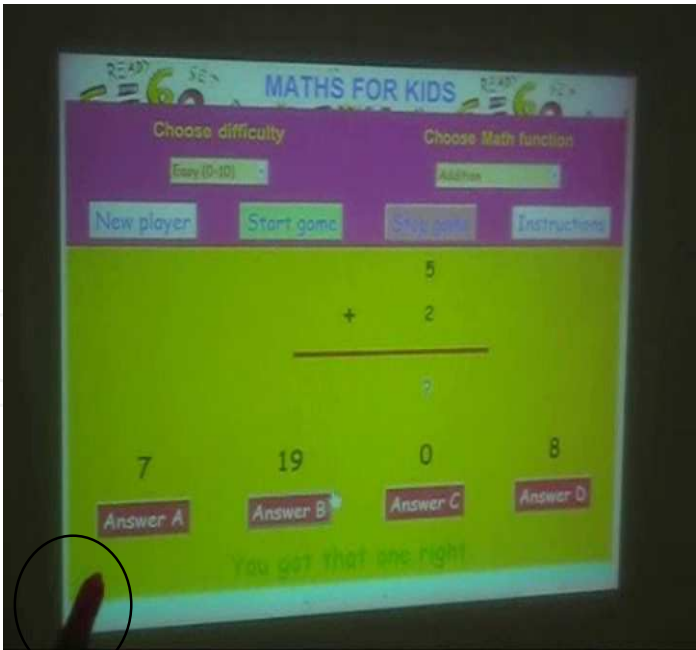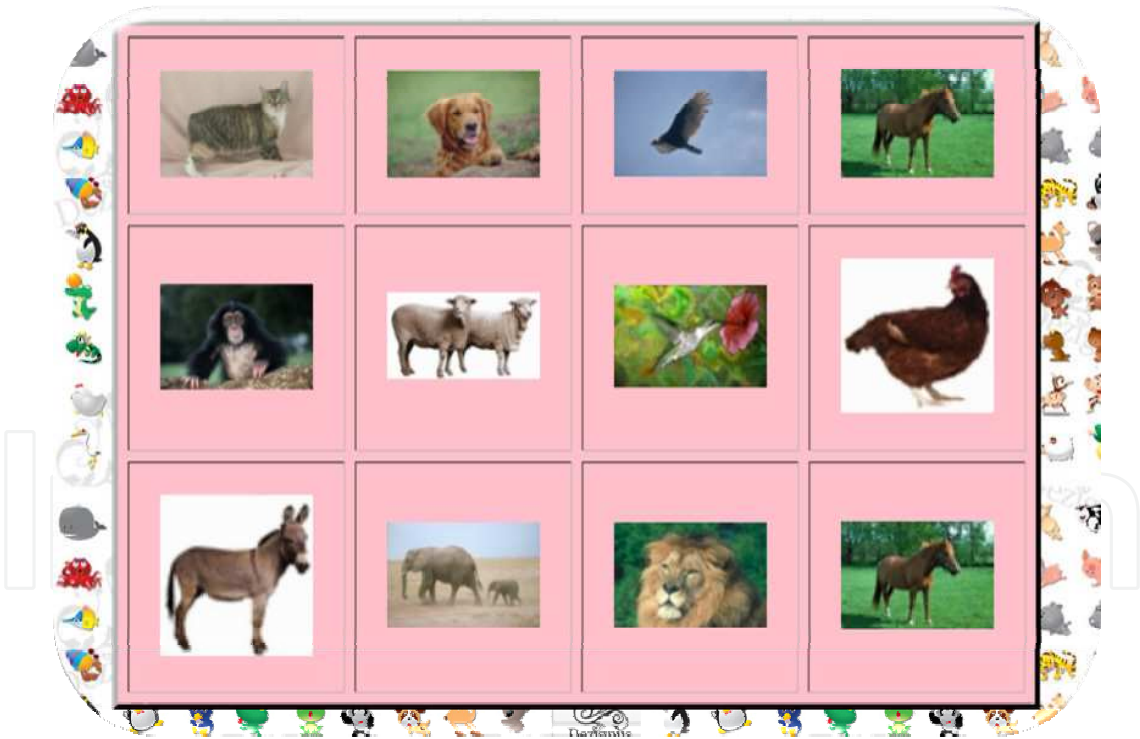
Fig. 13. Using ATB.

Fig. 14. Matching animals and voices game.

4.6 Assessments

ATB has been tested by some young students and teachers. The initial feedback is positive. We are in the process of getting permission to deploy the system in real schools for autistic children to have concrete surveys and statistics regarding how ATB affected their education

experience. In general, autistic children in Kuwait are exempted from using computers in their early years.

Some of the main challenges include the lighting of the class room. Since the application depends mainly on capturing markers using a web-camera, the lighting, background of the markers could affect the accuracy in some cases. The results of the initial testing on 10 students is shown on Figure 15. The students were asked to solve some exercises and the ease of use was estimated based on the time they took to solve the assigned exercises.
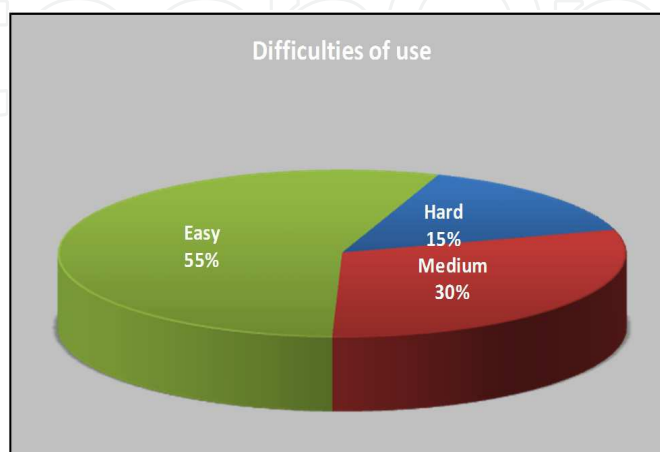

Fig. 15. Assessments for ATB.

4.7 Similar work

There are many technologies that are similar and related to ATB. CamSpace is software that enables users to interact with the PC using a webcam and without using a mouse or keyboard. CamTrax's [the company behind CamSpace] core technology is a pure software solution that allows most ordinary PC webcam (95% are supported) to track up to four objects in real-time and with reasonable accuracy and reliability [12].

Sixth Sense project was developed at the Media lab at MIT to provide a complete wearable gestural interface to mobile devices. Users of Sixth Sense use a camera, portable projects and their mobile phone to turn any surface to a smart projection surface [13]. The solution is economically feasible yet users have to be linked to some devices like the mobile phone and the projector which may cause problems in case of autistic children.

Gondy Leroy and Gianluca De Leo developed software for mobile devices to help autistic children communicate, make friends and blend in the society. The software mainly uses images for communication [15].

TWTD is educational software that uses markers and web-camera as a method of interacting with computers (to replace the mouse). TWTD targets mainly students with hand disabilities. Users of TWTD attach markers to that available parts of their hands (if any) and control the computer and educational applications accordingly. The markers are defined according to the level of disability. The users then get educated using computers in different subjects. The aim of this solution is to help physically challenged students who were not able to use computers to get educated in a creative way. Also the solution is economically feasible since it only requires a web-cam and a layer of software for interactions. There are several products that target the same problem. TWTD (since it used touchless SDK) remains by far more economically feasible [9].

5. Conclusion

In this chapter, we presented two solutions to help physically challenged students who suffer from different disabilities. We adopted the touchless SDK [2] to provide economical solutions for students with hand disabilities and autism. Both applications were tested in local schools in Kuwait. The intial results are promising and both projects are going through enhancements pahse now.

Future enhancements for TWTD

We are planning to add the following features to TWTD:

- Completing the intelligent tutoring subsystem that will customize the lessons based on the responses of the students.
- Tools to help tutors to design curriculum will be added to make it more friendly for tutors.
- A web-site to host tests and different subjects to be downloaded and uploaded by tutors.

Future enhancements for ATB

In the future we would like to add more features for the ATB system such as adding a virtual keyboard to let the child typing using his fingers only. Also we hope to create a full desktop for the autistic children where they can find different educational applications and other interesting applications such as painting and drawing applications and some music and entertainment applications. In addition, we are planning to use PLITS (Pattern Language for Intelligent Tutoring Systems) [3] to add intelligent tutoring features to ATB. Recently, we started planning to port applications to use Microsoft Kinect sensor for better performance. The next generation of both applications will adopt Kinect sensor to utilize its powerful cameras and sensors.

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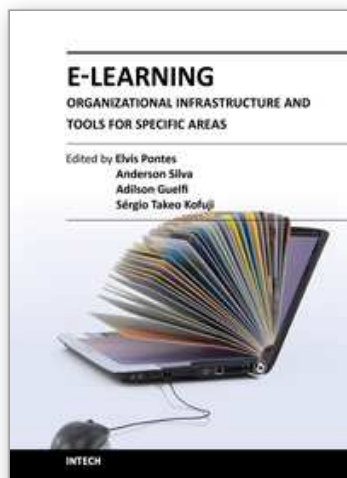
E-Learning-Organizational Infrastructure and Tools for Specific Areas

Edited by Prof. Adilson Guelfi

Technology development, mainly for telecommunications and computer systems, was a key factor for the interactivity and, thus, for the expansion of e-learning. This book is divided into two parts, presenting some proposals to deal with e-learning challenges, opening up a way of learning about and discussing new methodologies to increase the interaction level of classes and implementing technical tools for helping students to make better use of e-learning resources. In the first part, the reader may find chapters mentioning the required infrastructure for e-learning models and processes, organizational practices, suggestions, implementation of methods for assessing results, and case studies focused on pedagogical aspects that can be applied generically in different environments. The second part is related to tools that can be adopted by users such as graphical tools for engineering, mobile phone networks, and techniques to build robots, among others. Moreover, part two includes some chapters dedicated specifically to e-learning areas like engineering and architecture.

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