KinEd: A Kinect-based E-learning Platform to Enhance Collaborative and Kinesthetic Learning

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ABSTRACT
Delivering affordable education is one of the main millennium goals of the United Nations. Science labs are relatively expensive and hazardous. Dangerous chemical reactions, misusing the burners are two good examples of possible hazards. In this paper, we present KinEd which is a Kinect-based platform that provides students and teachers with an environment where they can download and upload different mini-games and learning tools for different school subjects in a way that encourages human interaction with the material to be learned. Students interact with KinEd using body gestures and postures to perform their experiments. We developed an API for gestures and postures then used it to develop KinEd. The current version of KinEd includes mini-games for chemistry, biology, physics and Mathematics. We will introduce the analysis and design of the tool and the API together with some snapshots of the environment and samples of the mini-games. We will also include initial assessments to verify the feasibility of using KinEd.

General Terms
Computer education

Keywords
Kinesthetic learning, education using games

1. INTRODUCTION
There are three main types of learners: Auditory learners, visual learners and kinesthetic learners. Auditory learners learn best by listening to things than reading about them. They mostly need a relatively quiet place to grasp material. Visual learners learn best by observation. Kinesthetic learners learn best by doing an activity. For them, sitting still while studying may be difficult. This type of learners prefers hands-on experiences over reading and observing [1]. A study conducted by Specific Diagnostic Studies found that 29 percent of all students in elementary and secondary schools are visual learners, 34 percent learn through auditory means, and 37 percent learn best through kinesthetic/tactile modes [3].

Because of the high ratio of kinesthetic learners, education is shifting toward a more hands-on approach. Hands-on teaching techniques are gaining recognition because they address the challenging needs of kinesthetic learners, as well as the diverse needs of auditory and visual learners [2]. We conducted a survey among sample of university students in Kuwait, around 56% preferred kinesthetic learning.

In this paper, we present KinEd which is a step towards providing an affordable collaborative e-learning environment that supports kinesthetic learners.

The rest of this paper is organized as follows:

- Section 2 includes background about the problem.
- Section 3 introduces the design of KinEd.
- Section 4 shows snapshots of using KinEd.
- Section 5 discusses similar solutions.
- A section 6 includes preliminary assessment by students and teachers.
- Section 7 concludes the paper and points to future directions and enhancements.

2. BACKGROUND
2.1 Environment Hazards and Cost of Labs
2.1.1 Hazards in labs
Science activities are diverse and often more difficult to supervise than other instructional activities. Anticipating, recognizing, controlling, and eliminating hazards require knowledge and understanding of safety issues. Even in simple elementary labs, safety precautions have to be well planned. In USA, Federal law requires that vendors of laboratory chemicals provide safety sheets for each substance they sell. The sheets provide detailed information about the physical and chemical properties, proper storage, disposal, toxicology, etc., of substances [6].

2.1.2 Cost of labs
Cost of science labs can be a challenge in some developing countries. In some cases, due to tight budget in schools, students never get the chance to perform their science experiments properly. Current solutions include the concept of mobile science labs [7]. MadaTech provides Mobile Science Laboratories that serve Israeli children in peripheral locations. The Mobile Laboratories cover many miles, as they travel to dozens of schools [8]. However, the availability of such mobile labs depends on many factors like the location and budget.

2.2 Relevant Technologies and Initiatives
2.2.1 Laptop for each child
Efforts to provide laptop for each child have been going for few years. The aim is to provide each child with an economical Internet-connected laptop [9]. Currently, there are many countries that benefited from the initiative.

2.2.2 *Kinect (motion sensor input device by Microsoft)* provides an interface to computers using body gestures and voice commands. Kinect has been widely used for games. Recently, research efforts started to adopt Kinect in medical and educational applications. Kinect is a motion sensing input device by Microsoft for both Xbox360 and windows-based PCs. Kinect enables users to interact with the Xbox 360 and PCs without the need to touch a game

controller, through a natural user interface using gestures, postures and spoken commands. Figure 1 shows the joints that can be detected by the Kinect sensor [5].

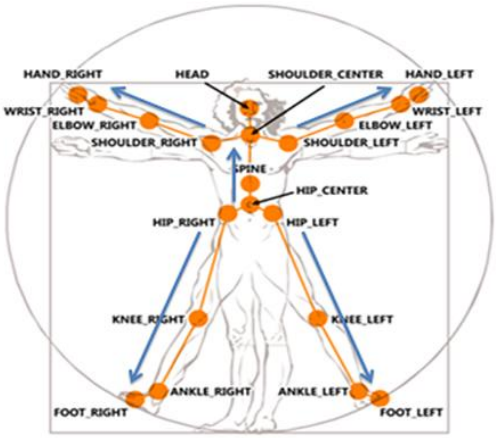

Figure 1 Joints that can be detected by Kinect [5].

2.3 Problem in more details

For many educational institutions, delivering information to different types of learners has always been a challenging task. The kinesthetic learning method has shown to be the most effective in absorbing information especially for kids, who learn better through play. The efficiency of the learning process improves when students interact with the learning material. While there can be interaction with various types of science experiments, subjects, such as English or Mathematics, are lacking the same type of interaction.

2.4 Solution

KinEd is a cost-effective Kinect-based environment that allows students and teachers to collaborate using a user-friendly interface. KinEd includes virtual labs and games that support safe kinesthetic learning in an economically feasible way. The main idea is to utilize and collaborate with other efforts like laptop per child to provide cost effective safe science labs.

3. KinEd DESIGN

3.1 Posture and Gesture API

Gesture and Posture API is one of the main components of the developed solution. The Gesture Analysis Module interprets the gestures of the users and prepares them to be compared to stored gestures. There are many types of gestures: gestures that have to do with knees, gestures that are related to heads and others related to hands position. The following are the gestures and postures that are supported by the developed API:

Gesture Recognition (Detect and bind)

- Swipe to left
- Swipe to right

Posture Recognition (Detect and bind)

- Left hand over head
- Right hand over head

3.2 Architecture and main users of KinEd

Figure 2 shows the architecture diagram of KinEd. The main input device is Kinect.

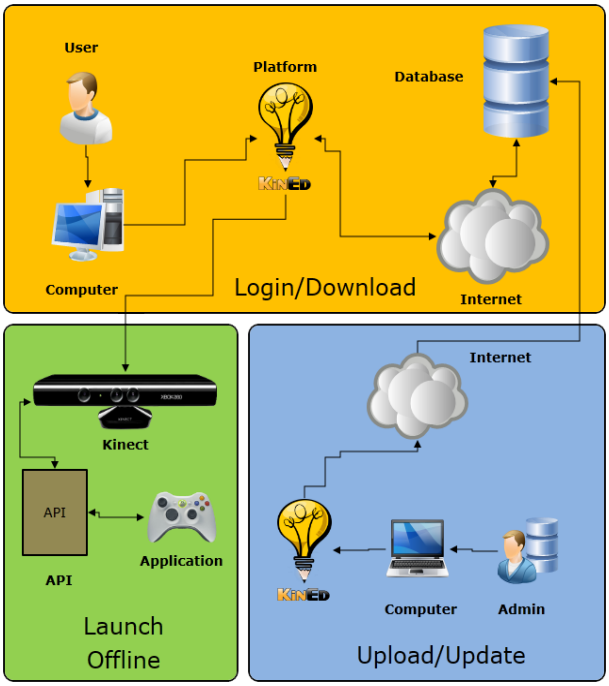

Figure 2 Architecture of KinEd.

As shown in figure 3, the user can do the following with KinEd. There are 3 main sub-systems: games, market and development.

Games

- Browse/play/delete downloaded games

Market

- Log in/out
- Browse the market
- Download/submit/rate a game

Development

- Create a game
- Browse/edit/delete created games

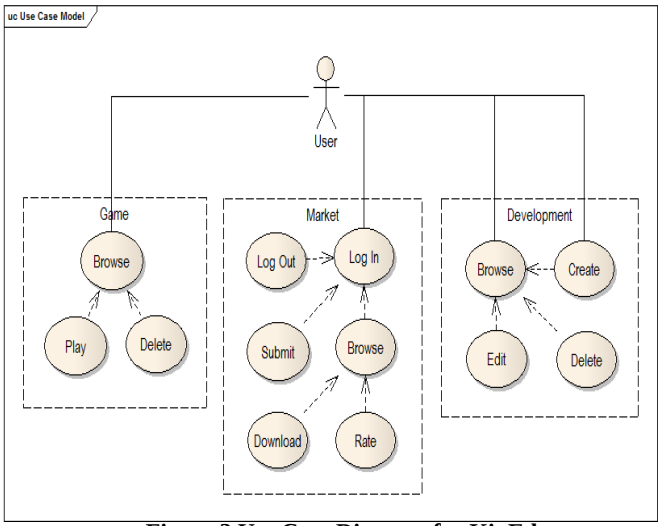

Figure 3 Use Case Diagram for KinEd.

3.3 Class Diagram

KinEd system consists of many classes. Amongst these classes, there are major ones that control the flow of the application. The Major classes (as displayed in figure 4) are: MainWindow, EngineManager, and all the "Game" related classes.

- MainWindow: This class is responsible for launching all other games within KinEd system
- EngineManager: This class is the manager of Posture, Gesture and Grab Engines. Its job is to forward all captured postures and gestures to associated engines for processing purposes and also to set the required events to certain Postures / Gestures. Each Game creates an object of EngineManager to be used through-out the game.
- MathGame: This class is a basic drag-and-drop addition and multiplication game.
- PhysLabGame: This class represents the Physics Lab that was done using XNA. It basically contains all the aspects of the game within it.
- Posture and PostureRecognitionEngine: These two classes model the set of identified postures and the engine that recognizes the postures. The postures are extensible to provide flexibility to add new postures.
- Gesture and GestureRecognitionEngine: These two classes model the set of identified gestures and the engine that recognizes the gestures. The gestures are extensible to provide flexibility to add new gestures.

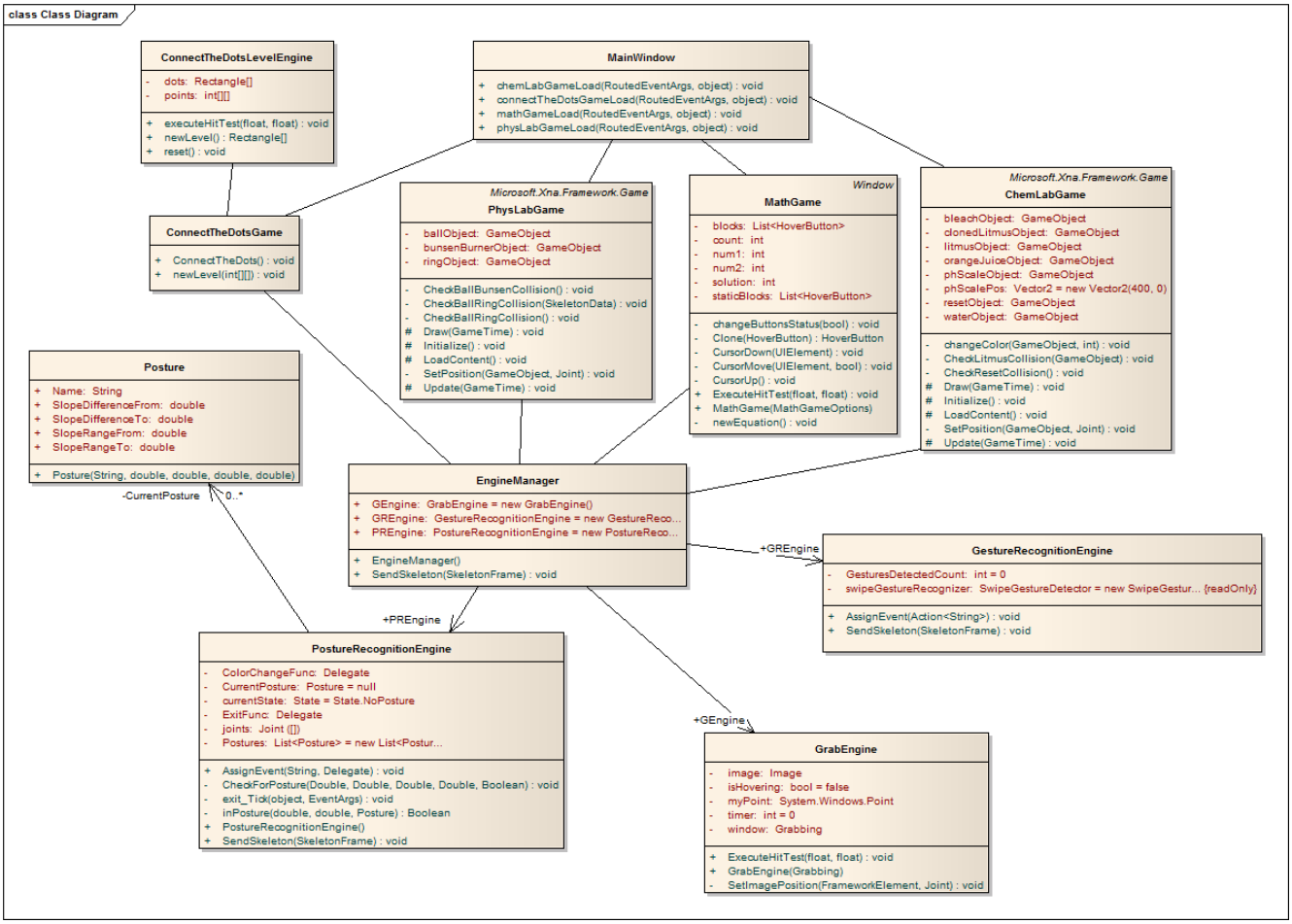

Figure 4 Class diagram for Major classes of KinEd.

3.4 Technologies Used

Most of the technologies used are Microsoft technologies since the initial prototype was one of the finalists of Microsoft Imagine Cup in Kuwait in 2012. The following technologies were used to develop the initial prototype of KinEd:

- Microsoft Kinect for Windows SDK Beta 2
  Microsoft .NET Framework 4.0
- Microsoft SQL Azure Cloud Database
- Microsoft Visual Studio 2010
- Microsoft .NET

4. USING KinEd

4.1 Marketplace

Figure 5 depicts the main marketplace interface. It mainly has two tabs: One that represents the games owned and downloaded and the other represents the available games in the Market. Once users download games, they are added to their current games tab. The interface is controlled using Kinect.

Figure 5 KinEd Market Place.

4.2 Physics Lab

The current physics lab prototype includes the famous thermal expansion experiment as shown in Figure 6. Even though, this experiment is simple, it has many hazards especially for kids since they have to use the burner. The main purpose of the experiment is to show and prove the concept of thermal expansion. The following are the steps of the real experiment[11]:

- Show students that the metal ball easily goes through the ring
- Turn on Bunsen burner.
- Hold metal ball above flame and heat for a minute.
- Try to put the heated metal ball through the ring (won't be able to do it)
- Put the heated metal ball in the beaker with the cold water
- Put the cooled metal ball through the ring again (should go in)

The same steps are done using the Kinect controlled simulation. Students interact with the game by dragging the ball using hand gestures. They will move the ball to the burner, pause for few seconds and notice the size of the ball expanding. Students will then drag the ball to the ring and try to see if it will pass. Taking the ball away from the ring and pausing for few seconds will allow the ball to shrink again. Students can then test it with the ring and record their findings.

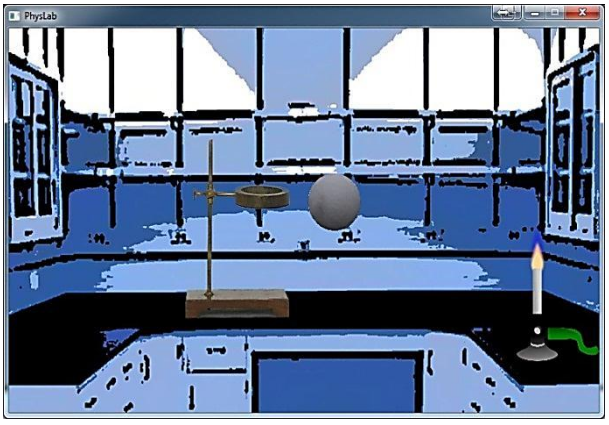

Figure 6 Virtual physics lab.

4.3 Chemistry Lab

One of the experiments that are commonly done in the classroom or laboratory is to use red and blue litmus paper strips to test a liquid as either acidic, basic, or neutral. The red strips look more pink than red and if they are dipped into a basic solution they will turn blue. The blue strips may look a bit more purple than blue, but they will turn pink (red) when dipped into an acidic solution. If the red and blue strips are dipped into a solution and they do not change in color then the solution is neutral.

One of the problems with conducting this experiment is to use solutions that are acidic or basic, but not dangerous [12]. Figure 7 shows a sequence diagram for the sequence of events a user takes to use the chemistry experiment. Figure 8 shows a snapshot of the developed experiment. Students interact with the experiment by moving their hands towards the box to the left to pick a litmus paper. The users drag the paper then to one of the three containers in the middle of the lab. Students have to pause for few seconds over the chosen container. The litmus paper will change color according to the liquid in the container. Students can then drag the litmus paper to the scale in the upper middle part of the screen to learn more about the nature of the tested liquid.

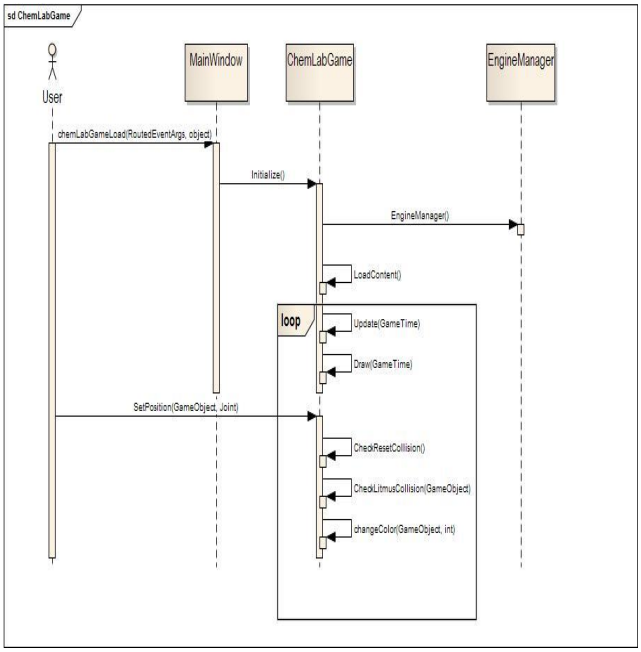

Figure 7 Sequence diagram for using the virtual chemistry lab

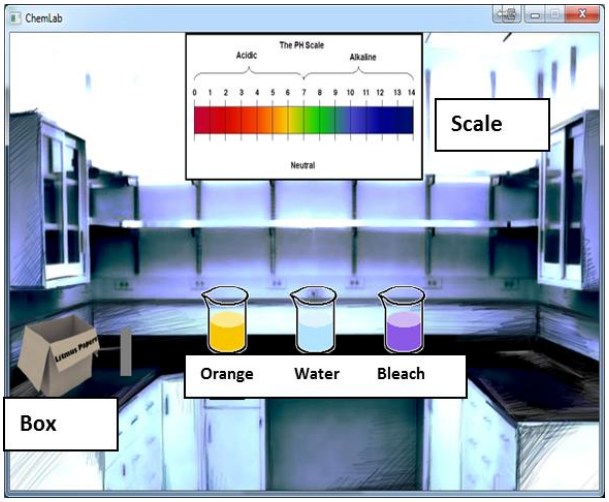

Figure 8 Virtual chemistry lab.

4.4 Biology Lab

KinEd uses the augmented reality to provide an interactive biology body parts illustration tool. The tool provides different views of body parts. Figure 9 depicts skeletal view that KinEd provides. Students stand in front of the Kinect sensor and can have access to the location of body part in different views: Muscular, Skeletal and organs. KinEd also scales to the body of the student trying to play. In addition, there is a feature where students are asked to locate certain organ by pointing. KinEd responds by indicating if it is the right answer or not. In addition, there is a magnifier where students can zoom in to see more details about associated organs.

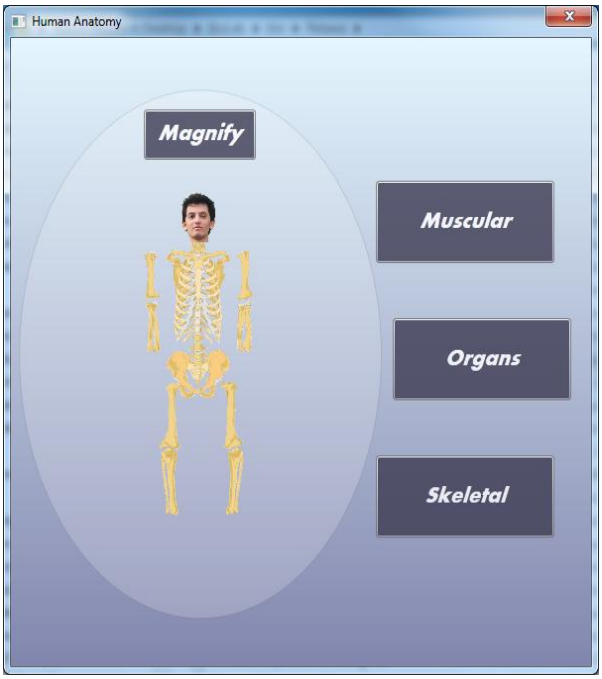

Figure 9 Virtual biology lab.

5. SIMILAR SYSTEMS

5.1 ITWorx Virtual lab

ITWorx released a product called virtual labs [14] as part of their educational software suite. The lab includes several chemical experiments and virtual substances. The lab is controlled by Kinect.

5.2 Mirracle

A team of Technical University of Munich has been working on developing an augmented-reality mirror. The main aim is to create an image that simulates human organs so that the user feels that he can see inside his own body. A prototype of Mirracle system was installed in the Academic Medical Center in Amsterdam in September 2011 [10].

5.3 MyPhysics Lab

MyPhysics lab has a collection of basic physics simulation mini java-based experiments. Simulations could be displayed on and offline [15]. It does not support Kinect interface though.

6. ASSESSMENTS

6.1 Teachers

Assessments by science teachers in schools were conducted. The following comments were collected out of the conducted survey:

- In some experiments, time plays an important factor. Using KinEd can provide great help in such experiments as students can control time.
- In some experiments, the availability of the material is very difficult and expensive. KinEd provides a reasonable environment to make up for real experiments in such cases.
- Awesome! I think students will enjoy this method of learning more than the standard method, and it will definitely motivate them and keep them focused. This is a great idea.

6.2 Students

The following are some of the comments we collected from students aged 8-10 after using the biology, chemistry, physics and math games:

- Interesting. I would definitely want to try it more. Using more than one sense can improve understanding the information.
- It was really fun playing the biology game.
- I tried the physics experiment in my lab and was very scared. Playing the game was fun and safe.

7. CONCLUSION AND FUTURE ENHANCEMENTS

The following enhancements are planned to improve KinEd:

- Multiplayer games: The current versions of games are single player games. We are planning to develop multi-player games where many students can interact with the same game using one or multiple Kinect sensors.
- Game Creation: Currently, we are working on game creation tool and integration with Scratch [19]. This way, students will learn programming using kinesthetic methods as well. They will write programs by using their body gestures and postures then they can share such games through the market place or Scratch web-site.
- More games and labs: We are planning to include the science curriculum of elementary school in Kuwait to start testing nationally.
- More authoring tools will be provided so that teachers can provide the experiments and curricula could be developed by crowdsourcing.

KinEd solves some of the challenges to education, like cost, by allowing more people in underprivileged areas to learn through the less costly virtual science labs. It also provides a platform for creativity and innovation. Through KinEd, students can collaborate to enhance the existing games and applications or to create their own applications. In addition, KinEd provides a completely safe environment for kids to try chemistry, physics and biology experiments. Another main goal of KinEd is to engage students in kinesthetic education in subjects like Mathematics and English.

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