Breathing Life into CPR Training

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Abstract. This study reports on our development and prototyping of an accessible, simplified simulation for teaching CPR in classrooms. The prototype involves an inexpensive digitally enhanced dummy that can be constructed from common available materials linked with an iPad or tablet running a customized program. The mobile program targets students at 5th grade and above and faculty for CPR training. iPad sensors register pressure manipulation on the dummy and the program responds with interactive instruction. Several tests with older youth and adults proved the simulation was effective in teaching simple CPR techniques that testers could remember the following week. With an improved dummy, we will conduct empirical tests across different age groups in the coming year.

Keywords: Physical cognition · Game theory · Simulation · Mobile learning

1 Background

The occasional accident happens all too often in K-12 classrooms: an athlete drops to the ground with an unexpected heart attack; the third-grade student chokes on a piece of meat; the swim team member inhales too soon after a dive. There are numerous health emergencies in the K-12 environment on a daily basis. When the accident results in cardiac arrest, staff, students and faculty are rarely prepared to save a life. In the US, the leading cause of natural death is sudden cardiac arrest. Approximately 70 % of Americans do not know how to give Cardio Pulmonary Resuscitation (CPR) or don't remember how. According to the American Heart Association (AHA) 88 % of all cardiac arrests happen at home and less than 8 % of cardiac arrests outside of the hospital survive. By the time emergency medical services (EMS) arrive, it is often too late. The reality is that anyone, from first grade to twelfth, as well as adults, can easily learn enough CPR to restart a heartbeat. One sure method of training for permanent retention is to use simulations [2, 5, 6].

California Congresswoman Lois Capps (CA-24) recently proposed a bill, "Teaching Children to Save Lives" (H.R. 2308) to fund elementary and secondary schools to provide CPR and automated external defibrillator (AED) training. We have developed a prototype dummy that can be used to answer Congresswoman Capps' call. It can be used to teach students and adults a safe and effective method for applying CPR, and as a physical simulation, promises to deliver a skill that can be easily learned and retained for a long duration.

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This research proposal hypothesizes that students will learn CPR training with the aid of a simulator dummy and be able to retain what they learn to the end of the semester; with long-term retention possibly as long as one year. Hands-on projects and simulations are effective at reaching underperforming students. With our prototype, we also hypothesize that the intervention will show that underachieving students perform as well or better than their peers in the test classroom. Success with a skill that can help students save lives has the potential to court students into life sciences, engineering or medical career paths.

2 Theoretical Foundations of the Study

The use of an iPad-based learning environment for our study provided access to the benefits of individualized learning, active hands-on learning, and the richness of multimedia and medical simulation technology to foster improved understanding and long-term retention of learning. We therefore joined a hands-on iPad application with a simulation activity for learning CPR in an interactive, kinesthetic environment.

2.1 New Technologies Foster Individualized Learning

James Kaput and Jeremy Roschelle [6] proposed in, *The mathematics of change and variation from a new perspective: New content, new context,* that a Dual Challenge existed with the growth of technology that required teaching "more math to more people" (section *Dual Challenges: Much more mathematics for many more people*, par. (1). They pointed out that, by the turn of the century, teaching mathematics had become increasingly abstract and complex in the face of increasing student diversity and social cost. While pointing out the advantages that new technologies offered, they concluded with the question "Can these new possibilities transform our notion of a core mathematics curriculum for all learners?" Their emphasis on "all learners" alluded early to the inability of mass solutions to meet individual needs. More recent work in artificial intelligence that allows for individualized instruction with solutions such as the Cognitive Tutor [7] or adaptive testing have run into the same constraints of increased cost, learner diversity, and complexity of content. Our challenge was to match individual learners to a learning simulation at reduced cost, thereby meeting Congresswoman Capps' proposal.

We chose to develop a mobile application for the iPad. While the iPad is potentially the most expensive component in the learning system, iPads are increasingly being used in K-12 classrooms. The app would be an additional potential use of an existing technology and one that attracts student interest.

2.2 Constructivism and Authentic, Hands-on Learning

The act of pressing, pushing, tapping and swiping on an iPad provides significant kinesthetic experience and immerses the learner in a hands-on learning experience. S.B. Issenberg [13] identifies ten key features of medical use of simulation that improves

learning, including: repetitive practice, immediate feedback, curriculum integration, capture clinical variation, and individualized learning to name those that are relevant. The benefits of constructivist methods that allow learners to explore the meaning of what they learn by studying with others and getting their hands into the lesson have been well documented [4, 10, 12, 14]. In this study, students physically "save a life" through simulation and thereby understand the elements of CPR that allow them to do so. They then teach their peers, their parents, and others, vastly improving their own retention of what they have learned.

2.3 Simulations Aid Learning and Retention

Simulations help bring concepts alive in the hands of every learner. When a student puts hands on the CPR dummy, they understand the life and death situation and they intuitively understand the subtle skills in what they are learning. Research has made great strides in understanding the potential of virtual games and simulations to engage learners and advance their learning as effectively or beyond the traditional lecture [5]. Games, virtual learning environments, and simulations have left laboratories and university classrooms and are being increasingly used in K-12 classrooms to bring the learning benefits to children and young adults and also to give students an introduction to and a taste of career opportunities and environments.

One sure method of training for permanent retention is to use simulations (see [2, 5, 6]). Karl Kapp [6] explains the success of simulations in teaching and uses the example of the T-Haler (a gamified and wifi connected inhaler) that showed "proper use of the inhaler can go from 20 to 60 % by using the T-Haler and playing the computer game to get it right" (p. 4). This study introduces students to the CPR simulation gradually by first involving them in tapping on the CPR mobile application, and then using the simulation in conjunction with a medical dummy.

2.4 Contributions of Multimedia

Richard Mayer's [8] Multimedia Learning Theory states that instructional messages should be developed in light of how the human mind works. Mayer's research shows how words and pictures are qualitatively different yet complement each other and that human understanding occurs when learners are able to integrate visual and verbal representations. Digital interfaces help bridge the gap between the learner and his or her understanding of the content being taught. According to Mayer, building connections between words and pictures, learners are able to create a deeper understanding than from words or pictures alone [8]. The CPR app presents a visual, interactive learning program that joins audio with visual cardiac readings, hands-on manipulation of pressure points, and text-based information all in a smooth simulated experience. Mayer explains that humans have meaningful and transferable learning experiences when they engage in active learning that allows the to pay attention to relevant information and organize it into meaningful mental representations.

We took these challenges and theoretical understandings into consideration in the design and development of the instructional dummy and iPad simulation. We then tested an early prototype simulation using the activities described in the Methods section that follows.

3 Methods

3.1 Creating a Simulation Mobile App

A CPR simulation application (CPR app) was written and developed for delivery on an iPad. The iPad was chosen for its visual screen real estate and sensor capabilities. The CPR app was instructionally designed to match the specifications of current CPR training. One major downfall of any CPR course is that there is not a way to account for how people will react in the real world. Creating a simulation of a real CPR scenario helps overcome that limitation. Also, Pearson [11] reveals that a majority (69 %) of elementary, middle and high school students would like to use mobile devices more in the classroom. The mobile application was developed for two approaches — using the iPad by itself and with a dummy. The basic simulation can be executed using tap gestures. When a dummy is used, the simulation becomes more realistic and has added features; for example, the dummy's eyes may open. The goal of the app is to train students who do not have any prior knowledge of CPR and it is designed to accustom students to the simulation environment by starting with a simple iPad action using tapping gestures, and then moving to the dummy simulation. The learners all have the same goal: the ability to save a life using the techniques learned from the CPR mobile application. The instructional goals are that learners will be able to:

1. Perform one-person adult CPR in an emergency situation;
2. Recognize and know the protocols when dealing with an emergency situation; and
3. Teach others how perform CPR.

The CPR app will maximize the iPad's technology. The application uses aspects of gamification to engage young learners and keep their interest through the hands-on interaction. The app starts with an e-learning module consisting of an interactive presentation with video, audio, and quizzes. The content covers general information about CPR, protocols on what to do in an emergency situation, and directions on how to give compression CPR. Quizzes check for understanding throughout the course. After the initial training, students will perform simulated CPR. Learners use the iPad's touch screen to perform compression CPR in one of the following two ways (see Fig. 1):

1. A simulation finger tap at the appropriate timing; or
2. A full simulation.

The iPad will be connected to a dummy mannequin for the full simulation. The mannequin's heart will stop beating and the students should react and practice by performing a full simulation. The iPad will use its accelerometer technology to determine if the students are compressing the chest at the right depth and pace. If the student is successful, they will have "saved a life." The app is recommended for use in

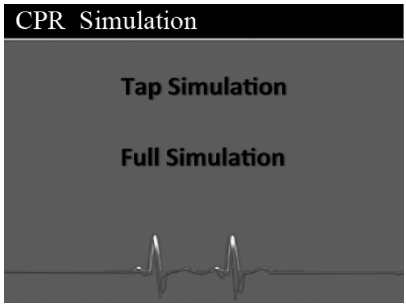

Fig. 1. The CPR app entry to the simulation screen showing a choice between the tap simulation with iPad only, or a full simulation using the medical dummy.

conjunction with teacher input. The students should take advantage of the app to teach others in their family how to give CPR. This is one of the most powerful tools of the app because it allows the student to transfer the knowledge while exposing more people to the life saving skills of compression CPR.

3.2 Teaching by Dummy

The completed simulation prototype will be constructed of a standard medical dummy (i.e., without specialized sensors or artificial responses) and the iPad attached on top (see Fig. 2). The custom iPad program provides the student with the interactive CPR training. The iPad is utilized for its sensitivity and orientation detection. An IEEE Abstract and full paper on haptic technology identifies that a primary application area for haptics has been in surgical simulation and medical training [1]. For our prototype, complex detection is not necessary and would greatly expand the cost. We have shown that the iPad can sense the actions of the learner effectively to render accurate

Fig. 2. A standard human dummy will be outfitted with an iPad running the custom CPR training program. The training program was tested and found effective with teenagers and adults showing a one-week retention. When combined with a standard dummy, the iPad capabilities for pressure and time sensing will be utilized to give a more realistic feel for students.

instructional response. The mobile application was built and tested to respond to pressure and counts. The application includes instruction in the CPR methods and provides practice through the simulation until the learner has acquired the skill. The testing environment worked when the iPad was placed on an inflated pillow that mimicked the actions of the chest during CPR. We plan to augment a dummy with the iPad or similar mobile tablet as shown in Fig. 1. We will beta test it in several classes using volunteers. We will retest the volunteers in the same skill in four to six months to determine if there is long term retention. Findings from the alpha iPad tests suggested a high level of skill achievement with small margin of error.

A one-hour training is available for people in the education field and covers the following:

1. Recommended implementation of the app;
2. How to use and update the app;
3. How to evaluate assessments;

4 Implications of the Study

We predicted that giving students and faculty direct hands-on simulated practice in compression CPR would help learners retain the specific procedural skills long term. Informal trials with a medic, a teacher, a nurse, and volunteer students suggested that there was good variety in tasks to maintain attention, the iPad was liked for the content, and the content was appropriate for the training. Changes were also suggested to the application to make it more effective:

1. Make clear the training is for Adult CPR;
2. Switch users out after 2 min;
3. Make the audio directions clearer when to move to the next screen
4. Add a disclaimer that while rate is important in the simulation, depth also is important and is not addressed.

Overall, this proved to be a solid prototype with an app that is effective for introducing students to compression CPR. The designer believes the final product of an e-learning module in an iPad is far more efficient then using an HTML 5 application. The HTML 5 export relies on the Internet as opposed to the app being in the iPad itself. This allowed users to use the app anywhere. This project can provide schools critical instructional content for their iPads and can help local EMS providers reach their goals of educating junior high and high school students on CPR. The fact that the basic mobile app can be used in the classroom for nearly no cost makes it a very viable option for K-12 classrooms.

The statistics on cardiac arrest survival are grim; yet, if a victim is given CPR immediately when EMS arrives, their chance of survival instantly doubles and can possibly triple (American Heart Association, 2013). Yet, the amount of bystanders who know CPR has dropped drastically over the years. In schools, the knowledge rate plummets further. The overall goal of the CPR mobile application is to increase the knowledge base of individuals starting at the Junior High School level in order to help

save lives in the community during an emergency. The mobile application has the potential to train people across the world on compression CPR. Although compression only CPR has been taught little in the past, research shows that compression is the most important skill when saving lives. Compression CPR is unique in the sense that it continues to pump blood to the brain (Lurie, et al., 1994). It can prevent a person from going brain dead until EMS arrives. This app will be an invaluable tool for school districts across the US. The mobile application also has the potential to empower students by giving them the skills to save lives.

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