VibRein: An Engaging and Assistive Mobile Learning Companion for Students with Intellectual Disabilities

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ABSTRACT

Massive Open Online Courses (MOOCs) have paved a new wave in the education world. Rich multimedia content coupled with mobile delivery mechanisms makes the content always available and engaging. This paper proposes VibRein to enrich the student interaction with multimedia learning content by making use of different sensors that are available on a mobile device to create an intelligent video consumption experience. VibRein as a companion is even more effective for students with intellectual disabilities who require some form of continuous supervision. It provides an assistive mechanism that keeps track of the user attention using the device camera (this can be particularly useful for students with attention disorder), and uses haptic feedback to recapture attention. In course of the video consumption, VibRein evaluates the learning by asking questions about the content in the video, and automatically force-rewinds to the location where the concept was explained if the user answers incorrectly. It uses tilt in four directions for response to questions, since touch, as a modality on mobile devices requires fine motor skills. An evaluation with 18 users with intellectual disabilities of various kind (autism, intellectual disability and attention deficit hyperactive disorder) suggests that VibRein can provide better learning with less intervention.

Author Keywords

Video, mobile device, forced playback, haptic feedback, face detection, mobile device sensors, tilt sensor.

ACM Classification Keywords

H.5.2 Information Interfaces and Presentation: User Interfaces–*Haptic I/O*, *Input devices and strategies, User-centered design;* I.4.8 Scene Analysis - *Object recognition;* H.5.1 Multimedia Information Systems - *Video*

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1 This work was done when Shubham and Saurabh were at IBM Research

INTRODUCTION

With the advent of MOOCs, the education world is going through a massive change (Attis et al, 2012). This coupled with a large repository of multimedia content is making learning increasingly self-paced with periodic intervention from the teachers or experts. Studies (Razzaq et al, 2005) have indicated that a limited classroom time compels teachers to choose between assisting students' development and assessing students' abilities. Some brick-and-mortar institutions claim that 80% of the learning by their students happens outside the classroom (Learning outside the classroom, 2006). The other compelling trend is the mobility that is enabling consumption of multimedia content and learning to happen anywhere, anytime, and with anyone. Mobile devices for education are also being increasingly popularized by government initiatives in various countries (Future of Mobile learning, 2013). These trends suggest that products that act as companions and augment the teacher instructions with multimedia content on mobile devices can help improve the overall learning outcome of the students.

The problem however with offline self-paced learning is that there is no way to know how attentive the student is while consuming the content; how to bring back the attention of the user to the learning task if distracted; and how to continuously evaluate and reinforce the content until the student has learnt the content thoroughly. Such monitoring and interventions are performed though by the teachers on a daily basis in the classroom. In this paper we propose VibRein which aims to augment the learning outside the classroom by mimicking some of the behaviors that a teacher displays in everyday instructions in the classroom to improve students' learning outcomes. It enriches a student's interaction with multimedia learning content by making use of different sensors that are available on a mobile device to create an intelligent video consumption experience

VibRein uses the front facing camera on the mobile device to perform face detection that is used as proxy for attention when the user is viewing some content on the display. VibRein uses the vibration feature of the phone to provide haptic feedback and bring the attention of the user back to the content. VibRein evaluates the learning by asking questions about the content in the video, and if the user could not answer correctly, VibRein automatically rewinds to the location where the concept was explained and this continues until the user answers correctly. Since touch as a modality on mobile device requires fine motor skills, VibRein allows the users to respond to the questions (for four choices) using four direction of tilts detected by the tilt sensor on the mobile device.

Though VibRein fills an important gap of augmenting the teacher outside the classroom for all categories of students, for the evaluation purpose we chose a group of users in a special school who have disabilities such as autism, intellectual disability and attention deficit hyperactive disorder. This group of users requires constant supervision by their teachers, parents or caretakers. This continuous supervision results in them being frustrated and affects their confidence of being able to do things independently. However, it is also hard for them to learn a concept without any supervision. VibRein as a companion to these groups of users fills an important gap. The feature to be able to tilt the phone to answer questions instead of touch was targeted at these groups of users who have problem with touch on the mobile devices since it requires fine motor skills. Tilt can also be useful for blind users who cannot use touch at all. The user attention feature of VibRein can be particularly useful for the users who have attention deficit hyperactive disorder to be able to provide alerts during their learning process. We studied a group of 18 users comparing VibRein with the current video consumption experience (using the inbuilt video player of Android) and found that the users were more engaged, excited, and learnt more efficiently and effectively as compared to a simple video consumption experience. Though we could have done the evaluation on a larger set of users, the readers would appreciate the fact that this group of users were very difficult to manage from a study point of view and required a lot of iteration to get the technology and users in right alignment for the study.

Contributions

Following are the three core contributions of this paper

1. *Forced playback for reinforced learning*: We introduce the concept of forced playback of a content on the video player when a user fails a test for a concept or content.
2. *Evaluation of our mobile learning companion model and interactions on intellectually disabled users*. Our paper provides some interesting insights and understanding of bringing augmenting technology to these group of users. For example use of tilt as an interaction compared to touch was more easily handled by these group of users.
3. *Attention measurement and intervention*: We attempt to measure attention of the learner consuming a content on the mobile device using frontal face detection as cue, and use the haptic feedback as a mechanism to intervene when attention is missing. The bring to fore the importance of attention measurement in learning scenario which can be correlated to the performance of the user in the tests about the content/concepts in the video to understand more closely the cause of poor performance.

In this paper, we first present the research that has been done in the area of video playback and haptic interactions on mobile devices and position our research with respect to this prior art. We then present insights that were derived from an initial field study to the schools for intellectually disabled students. These insights were used to design VibRein, the interaction styles of which are presented next. We then describe the implementation details of VibRein, which was developed as a solution on the Android platform. Finally we present our experience of using VibRein with 18 participant users and report the observations while comparing the VibRein with a standard video player. We conclude the paper with a discussion on the future capabilities of VibRein by exploiting the richer interaction features being available on smart phones.

RELATED WORK

Forced playback and video manipulation has been used to help people learn using training videos by automatically pausing at places that requires attention and asking the user to replicate a task (Pongnumkul et al., 2015). Some tools allow manipulation of the video content for ease of browsing and content creation (Denoue et al., 2013; Hurst et al, 2008; Karrer et al, 2009). Features such as use of eye detection to play or pause a video is available in many mobile devices today such as Samsung, LG, Micromax etc. However, they are meant for purely passive video consumption which does not require the user to interact with the information in the video. To the best of our knowledge, our technique of forced playback is unique for educational video consumption where the user is tested for the content and taken back to the location where the content was explained if the test fails.

Measuring engagement with content or activity has been studied using various cues such as mouse clicks, browsing behavior, gaze etc. (Jiang et al, 2011) uses these cues to create a personalized recommendation for content with which the user was more engaged in the past. Authors in (Bixler et al, 2013) use key-stroke analysis to infer engagement or boredom levels of users in a writing task. Use of facial analysis to manipulate user interfaces has also been well studied in (Valenti et al., 2008; Vrzakova et al., 2013) and also available in products in the market such as Samsung mobile phones. Haptic as a technique to improve video consumption experience or provide feedback to users for various tasks is also well studied. There is research on using haptic feedback such as knobs and wheels to create a more expressive video consumption experience (Scott et al., 2001). Haptic feedback has also been used to guide users in transportation scenario when other senses maybe limited due to weather condition or engaged due to the task of driving at hand (Sucu, 2013; Steltenpohl et al., 2013). In our work we use frontal face detection as a proxy for inferring attention for users and use it in combination with haptic feedback to complete the loop of bringing the user attention back to the task if attention is lost. The detection of attention has lot more deeper significance in a learning scenario where a post analysis can reveal why a learner did not perform well.

Tilt interaction on mobile devices has also generated a lot of interest. In (Dachselt et al., 2009), the authors propose to use tilt to improve the interaction of a mobile device and a large display. The mobile device is used as a remote and the tilt can be used to control various functions on a large display. Interaction with virtual 3-D environment using mobile device tilt as a controller has been studied in (Du et al., 2011). We use tilt primarily for two reasons: a user group who are not comfortable with touch on small display mobile devices, and keeping precious screen real-estate clear of overlays which can hamper the consumption of content on device.

There has been a lot of psychological research on students with intellectual disabilities. Consulting and clinical psychology research has provided instances of behavioral treatment to improve learning for autistic students (Lovas et al., 1987). They also report that medical intervention has not been as successful for such students as compared to psychological interventions. Symbolic play (and hence tilt and physical interaction) was considered to be more effective for autistic and mentally retarded children (Wing et al., 1977). Not much research has been done on applying mobile technologies for intellectually disabled students. However, there has been an application of robot technology for rehabilitation of autistic children in the past (Werry et al., 1999).

In light of this related work, we believe the VibRein is nicely positioned to use novel interaction techniques for a unique set of users, thus forming a good match of technology with a practical use-case.

DESIGN CONSIDERATIONS

We conducted an initial field study at two schools (names not mentioned for anonymity) that cater specifically to students with intellectual disability. These schools had students of varied age (from 3 to 45 years) and of different intellectual disabilities (intellectual disability, autism, attention deficit hyperactive disorder – ADHD). The purpose of this study was two-folds: observe the students and determine a sense of their comfort with mobile devices, and interact with the staff to understand the challenges that these students currently face in terms of learning educational concepts. We interacted with five staff of the school that had understanding of the students, had experience with interacting with these students and were exposed to teaching concepts. We observed more than 50 students of different mental age and a variety of disability.

The interaction with the staff and observation of students provided the following key insights:

- The students are mostly supervised throughout their daily activities. They are being told by the instructors or parents about what should be done and how, for each activity. This results in them being over-burdened by such continuous instructions.
- Students have an attention deficit, which is significantly higher than mainstream students. While the deficit is different for each student, depending on the mental age and specific type of mental disorder, but lack of ability to focus on a specific task was generic.
- The students were comfortable in interacting with a touch-screen mobile phone, and so were able to do interactions like touching and sliding. However most students did not understand the implications of such interaction. As an example, students tend to press whenever they would see a button, but without the semantics of the action of pressing the button.
- While reading a text, most students would trace the word that they would be speaking by touching the text through their finger, whether it was a book or a mobile phone from which they were reading the content.

While these observations and insights vary significantly with each student, the presented generalization was more to guide our design of VibRein as a possible solution to a broader community. VibRein was designed to ensure that the student could independently learn a given concept without any human supervision. The combination of forced playback, frontal face detection and vibration to get the attention back was provided to handle attention deficit.

The concept of providing answers through tilt rather than touch was influenced by the observation that the users touched the screen for reading the questions and answers. The overall design of VibRein was such that a user could interact with the content on his own, without any human supervision, in line with the observation about the users being always supervised. The staff mentioned that the implications of not needing to supervise were also considered to be important for the parent. If a parent could get some time wherein they did not have to supervise these users, that would be very valuable. The initial field study therefore defined the design of VibRein.

INTERACTION STYLES

VibRein provided three specific interactions to the users. The users are expected to hold the phone at a specific distance, as shown in Figure 1. If the user starts to look somewhere else rather than at the mobile screen, the front camera of the mobile detects this activity and vibrates the phone to bring the user attention back to the screen. The face detection is performed on every frame that is captured by the front camera. However the lack of attention is triggered only when no frontal face is detected for a significantly large amount of time. The second interaction is with respect to answering the questions. These questions are embedded within the video. As an example, in a 5 minute video, there could be 3 questions that are at 1 minute, 2 minute and 5 minute from the start of the video. Whenever a question is presented, the user has the option to choose one of the four answers. The mechanism to choose the answer is by tilting the phone as shown in Figure 2.

Figure 1. Use of frontal face detection to see if the user is not looking at the screen; use of vibration to bring the user attention back to the screen.

Questions are placed at different points in the screen (Figure 6) so that it becomes intuitive for users to tilt the phone to a position where the question is physically placed. The idea is to tilt the phone towards position of an answer.

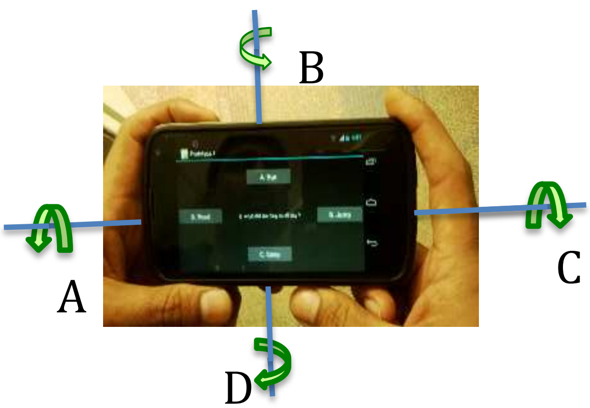

Figure 2. Tilting the phone to answer a multiple-choice question.

The third interaction is with respect to forcing the control of the video playback by not allowing any navigation buttons on the video. This ensures that the video continues to play even if a user touches the screen during playback. This also ensures that the video is able to move to specific points if the user was not able to answer the question correctly.

IMPLEMENTATION

VibRein has been designed to adapt to any educational video content. It takes two inputs: the educational video and the *Evaluation Sheet*. The *Evaluation Sheet* is authored in a comma-separated format. It contains the question, the four possible answers, the correct answer, the time location of the question (Start Time) and the time location in the video where the question has been explained (Concept Time). A sample evaluation sheet is shown in Figure 3.

Index	Start Time	Concept Time	Question	A	B	C	D	Correct Answer
0	134	69	What did the frog do all day?	Run	Jump	Sleep	Read	C
1	370	326	Where did the frog lie down the whole day?	Bed	Leaf	Grass	Tree	C

Figure 3. A sample Evaluation Sheet.

The architecture of VibRein is shown in Figure 4. It consists of a content controller that has the following three components:

Evaluator: The *Evaluator* takes inputs from the face detection system and the tilt detection system. The face detection system returns a binary value, suggesting whether the user is looking at the mobile phone screen or not. Based on this input, the evaluator triggers the *Navigator* to provide a haptic vibratory feedback to the user.

The *Evaluator* gets the direction of the tilt as another input. Then it maps the tilt direction to a specific answer, determines whether it is correct or not and then takes the next action through the *Navigator*. If the answer is incorrect, the next action would be to restart the video from the point where the concept related to the question was explained. If the answer is correct, the video continues forward.

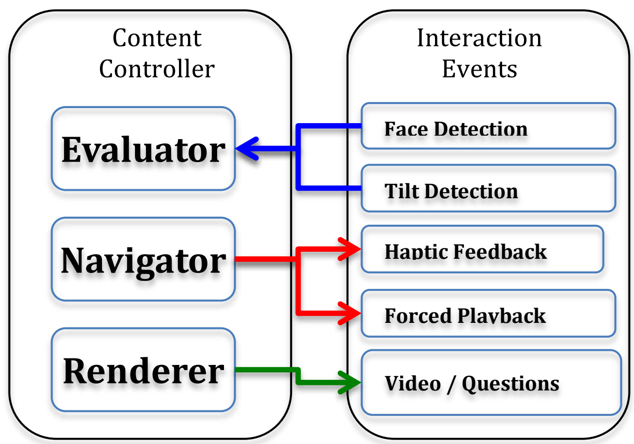

Figure 4. The VibRein architecture.

Navigator: The *Navigator* is driven solely by the *Evaluator* as explained above and controls the playback of the video in addition to providing haptic vibratory feedback to the user. It takes inputs from the Evaluator about the type of event (playback or vibration) and details about the event (what time of video to play or duration of vibration). The Navigator then generates the appropriate interaction events.

Renderer: There are two types of content to render in VibRein. One is the video content and second is the question-answer information. The video content is a separate media object that is directly played out on the user screen. The *Navigator* controls the duration of video that needs to be played. The question-answer content is a screen as shown in Figure 6, which has a question at the center and the four possible answers at different sides. The *Renderer* gets a cue from the *Navigator* and then either plays the video starting from a specific time or shows the question-answer content.

The *Evaluator*, *Navigator* and the *Renderer* drive the necessary Interaction Events, which are now explained below:

Face Detection: We use the Camera.FaceDetectionListener that is provided as an API with Android 4.3. This listener captures frames at a specific rate and the listener notifies whether a face is detected or not. The frame rate is dependent on the phone hardware, but varies from 5 frames per second (for Samsung Galaxy S) to 20 frames per second (for Samsung Galazy Note 2). Since we used frame detection as a background process, the frame rates are lower than the ones that we get when frames are shown in preview. VibRein extracts each frame and passes it to the face detection listener and converts its output to a binary value that suggests whether a frontal face is present or not. We scan each frame and then look for a face in a 3 second window. If there is no frame detected in this 3 second window, we label this as loss of attention.

Tilt Detection: Whenever a question is presented to the user, the direction of the tilt determines the user response to the question. VibRein uses the ROTATION_VECTOR sensor available as an API in Android 4.3. This sensor takes inputs from the accelerometer, compass and the gyroscope present on the mobile device. When the tilt is more than 60 degrees in a particular direction, we label that as a valid input from the user and pass the information to the *Evaluator*. We kept the tilt angle to be 60 degrees to ensure that there are no false matches as a result of user moving the phone accidentally.

Haptic Feedback: When the Evaluator determines that the user attention is lost, it signals the Navigator to generate a vibration for 1 second by using the Android VIBRATOR_SERVICE. After every 3 seconds of not detecting a frontal face, the phone vibrates for 1 second.

Forced Playback: When the *Evaluator* detects that the user answer is incorrect, it signals the Navigator to start the video from the Concept Time (as shown in Figure 4) for that particular question. This is achieved by using the seekTo() function available in the MediaPlayer class in Android 4.3. If the question is answered correctly by the user, the video continues to play from the point it was interrupted by the question.

Video / Questions: The *Navigator* uses the *Evaluation Sheet* to determine when to pause a video and show the question-answer screen. When the user answers the question, the information is passed through the Evaluator to the Renderer, which then switches back to the video from the static question-answer screen. This switch between the video and the question-answer screen is done by the renderer and this switch is clearly noticed by the user through change of the screens.

VibRein was implemented using the native Android SDK and can work on a phone that supports Android version 4.3 and has the required hardware to support face detection. We tested VibRein on Google Nexus 4 and Samsung Note 2 phone devices. The studies mentioned later in the paper were conducted on these two phones.

In order to compare VibRein with a typical video player, we also implemented a baseline system that used the same questions and answers, but enabled a user to respond to questions by touching buttons on a touch screen. The baseline system also had the standard video navigation controls to allow user to move to specific parts in the video.

DESIGN ITERATIONS

Before conducting the actual experiment, we demonstrated the VibRein system to the staff and received their feedback. We also asked five students to interact with VibRein system to identify potential bugs and design flaws in our prototype. We observed that users were more sensitive to the audio than the video. They would be more attentive to the video content if the audio in the content was clearly audible. The setting was such that the volume of the phone speaker was not sufficient to capture the user attention. Sounds from the other classrooms and events around often distracted the students from watching the video. We therefore provided earphones to each student who participated in the study.

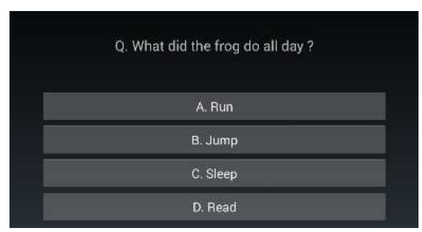

Figure 5. Initial layout standard for answering the questions.

In our first prototype, the layout of presenting the question and the possible answers followed the order as shown in Figure 5. We had to tell the participants that they should remember how to tilt the phone for providing a particular answer choice.

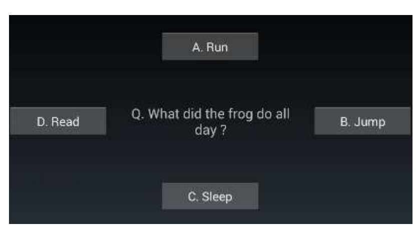

Figure 6. Changing the standard layout to positioning the question and possible answers to make tilt intuitive.

It was hard for these students to remember the four options and their corresponding tilt directions. The school staff then suggested the layout design as shown in Figure 6 and the system was modified to make the change. The school staff also observed that the students were not feeling encouraged when they provided a correct answer. So we created a separate screen (Figure 7) that explicitly mentioned whether the question was answered correctly or not. Additionally, we put in background sound of claps to encourage the students and so improve their engagement with the prototype.

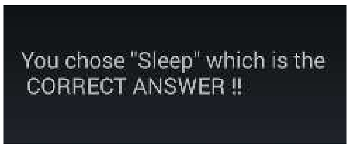

Figure 7. Explicit mention of correct/incorrect answer after the student response.

The initial prototype of VibRein had the *Forced Playback* enabled infinitely till the student answers the question correctly. At times, this lead to user frustration in cases when the student was not able to answer the question correctly despite watching the video many times.

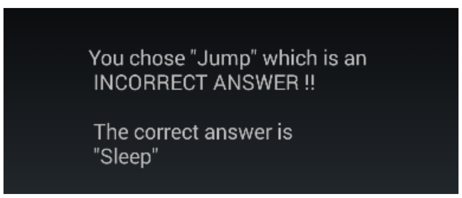

Figure 8. The video proceeds after the third attempt, informing the user of the correct answer.

The staff observed that if a student was not able to answer a question correctly even after three attempts, it is unlikely that the student will be able to understand the underlying concept and so it is better to move further in the video rather than increasing the user frustration while playing the same snippet in infinite loop. Therefore we made the change to VibRein such that it would move forward to the next video segment after the third incorrect attempt, after providing the correct answer as shown in Figure 8.

EXPERIMENTAL SETUP

During this design iteration phase, we also asked the school staff about the type of content that would be best to test the VibRein prototype. The staff suggested to pick a story from the book that was being taught at the school. We searched an equivalent video story and used a 280 seconds long video to evaluate VibRein. In order to compare VibRein with the baseline system, and yet not encounter learnability of the video across two prototypes, we selected another story "The Ugly Duckling" that had similar comprehension requirements. This video was 356 seconds long.

Study Formulation

Following were the key goals of the study:

1. Will VibRein be a more engaging mechanism and can it help users to avoid distractions and bring the attention back on the educational content?
2. Will students learn the concepts explained in the video any better in the VibRein system, perhaps due to the forced playback or due to them being more attentive?
3. Will the tilt based answering mechanism in VibRein provide a better navigation than the touchscreen?

To get answers to these questions, we performed a controlled study with 18 participant students. The following sections describe the demographics of these students, the study method and our quantitative and qualitative findings.

User Demographics

The experiment was conducted with 18 participant users. All participants were intellectually disabled children, aged between 12 to 18 years. All of them were enrolled in different classes across two special schools in New Delhi, India. Ten of the 18 participants were diagnosed with Autism Spectrum Disorder (ASD) while 8 were participants were in the Intellectual disability (MR) category. There were female participants and nine male participants. The participants were selected by the school staff, taking into consideration the intellectual, motor and comprehension ability required to attempt the tasks.

Figure 9. Participants using VibRein in presence of a school moderator (A) and using touch Screens (B, C & D).

Study Method

The VibRein prototype (referred to as P1 in this section) and the baseline prototype (P2) were both evaluated using two different videos: "The Lazy Frog" (V1) and "The Ugly Duckling" (V2). In order to not bias the results either through the order of prototype or the combination of videos, each participant was asked to interact with one of the following combination of prototypes and videos: P1V1 -> P2V2, P2V2 -> P1V1, P1V2 -> P2V1, P2V1 -> P1V2. This ensured that each participant gets to interact with both the prototypes, while at the same time no prototype is specific to a particular video. The distribution of these four possible order was attempted to be equal among participants.

Each participant was supposed to answer five assigned questions through the two prototypes installed on a touch screen mobile phone. Each participant was met individually, and was introduced to the study, the prototype and was provided instructions on operating the prototypes. At least one school staff was present during the study, to make the student feel more comfortable. The study itself was conducted in a room in the same school where the student was enrolled in. This ensured that the surrounds were familiar to the student. During the course of the participants interacting with the prototypes, the researcher observed their behaviors and actions while interacting with the system. These were noted and later analyzed to derive the qualitative findings. At the end, participants were asked of their prototypes and video preferences.

RESULTS

All participants attempted to view the whole video and answer the five questions. Each participant also offered several verbal comments to moderator about both the prototypes they had been asked to use. We discuss our findings below, comparing VibRein with baseline system.

Accuracy

The Overall accuracy was observed to be better in case of VibRein (P1) prototype. Out of a total of 70 questions attempted by the 18 users in P1, users were able to answer 68 correctly. While the same numbers for P2 were 49 correct answers for 75 attempts. Ideally there should have been 90 (18x5) questions attempted for both prototypes. However not every user managed to watch the entire video and so did not attempt all questions. This is expected because of the profile of the users. For P2, we observed, that hardly any participant went back to the video to look at it again in case they did not answer the question correctly. On the other hand, P1 forced the users to watch the video again in case of a wrong answer. We also observed that while looking at the video the second time, the user would speak out the answer as soon as they saw the event in the video. As an example, when a user was not able to answer the question "*How many eggs did the duckling lay,*" then while watching the video second time, as soon as the video showed the eggs, the student would speak out the answer. This validated our second hypothesis of VibRein being more effective in explaining the concepts. Moreover, in touch screen prototype, many participants seemed to know the answer, but they accidently tapped another option.

	P1	P2
Accuracy (in %)	97.14%	67.33%
Number of Attempts	95	75

Table 1. Accuracy and number of attempts for two prototypes.

Forced Repetitions for an Attempt

Our assumption was that if a navigation technique would be easy to use, then the participant would be interested in watching the video segment again to attempt to answer the question more than once. For P1, users took 100 attempts to answer 70 questions. This reinforces the earlier finding that students tried to re-attempt a wrongly answered question by watching the corresponding video segment. However for P2, users did 75 attempts for 65 questions; the 10 additional attempts were also done by the students only when the researcher requested them to watch the video again. For P2, we observed very less motivation for trying a question again even if the answer went wrong. Thus the technique of forced repetition worked well with these participants as compared to providing them an option to choose to repeat.

Response time to answer a question

The VibRein prototype (P1) was expected to take more time, owing to the interaction technique of the tilting the phone, yet we observed a non-significant difference in time taken to complete tasks with both prototypes (Table 2). Mean time to a complete task was calculated as the time between video pause event and participant providing an answer (either by tilt or touch). When compared, the difference in time taken to respond in cases when the answer was correct was even lower. When we analyzed the response time for cases when the user had seen the question earlier (i.e. repeat attempt), the P1 prototype took more time than P2. This validates the fact that the interaction time for providing the response by tilting the phone is more than the time that it takes to answer a question by touching a button. However, we believe that the correctness of answer is more critical to these students as compared to response time.

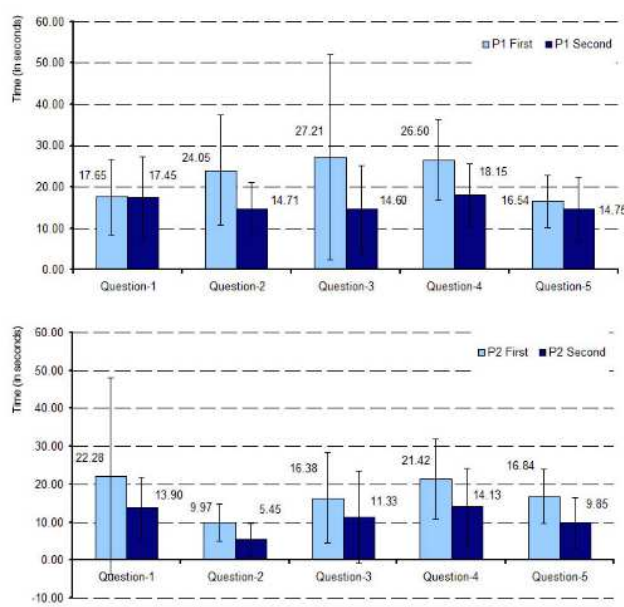

Figure 10. Mean Time in Task completion in two prototypes in different order of attempts.

To sanitize results with respect to the order in which the prototypes were presented to the users, we analyzed the response times for each question based on whether the user had interacted with P1 first or second. Figure 10 shows a comparison of both prototypes in the order of presentation. No significant difference was found in the order of presentation, for P1 (CHI square = 0.015< 9.488; df=4) and P2 (CHI square = 0.016< 9.488; df=4). This proves that there was very less learning from P1 and P2 and vice versa. This could be attributed to the to the slow learning capabilities of the subjects and to the completely different interaction styles of the two systems.

	All Entries	Correct Answers	Second Attempt
P1	19.15	17.37	12.89
P2	14.53	14.04	8.59

Table 2. Accuracy and number of attempts for two prototypes.

Since focus of the experiment was to maximize accuracy and not the time taken for task completion, our results explain that P1 was better than P2 owing to high accuracy while not taking significantly more time during interaction.

OBESERVATIONS & DISCUSSIONS

Ease of use of VibRein

When asked casually by researchers, the participants were able to provide some feedbacks for likeliness for a system. Six out 18 participants found VibRein very easy, while other 6 liked touch screen Interactions. Remaining 6 refused to make a comparison and said that they liked both the prototypes. Due to the lesser cognitive ability of these participants, especially with respect to making a decision, researchers didn't quiz the participants for a specific answer to the qualitative questions. However, the school moderators who were the part of the experiment and were briefed initially about two designs, liked the overall interaction for P1. One of the moderators, who was a school teacher said enthusiastically – "*Children like to play with physical objects. They try and grasp basic concepts through speech and touch. They would love to use VibRein because of the physical movement involved*." During the study, we observed that participants were happy to know about VibRein, which was a new concept to them. During the interview, there came a lot of questions such as: *How does this work? How much rotation should be done? I am doing it correctly?* User Experience of this system was perceived to be high and a lot of students commented – *it was fun!*

Rotation of VibRein on the Smaller Edge

Though VibRein was perceived to be very effective in providing the educational content, we observed few challenges with some users while responding to questions. For first time use, it was easier to tilt the phone in the x-axis, however it was little difficult to tilt it over the y-axis, specifically towards the right side. We also observed that determining how much to tilt was also difficult for the participants. In VibRein, the way a participant held the mobile phone was a determining factor in the ease of use. One of expert of Physical Education in the school said – "*There are some restrictions with these children related to physical body movement. But they generally adapt over a period of time*" We believe that with intervention of parents and children, rotation across y-axis would also be as easy.

Vibrations and User Attention

Most participants noticed when the phone vibrated. We also observed that there were a lot of instances when the users would look elsewhere, either because there was an activity in the surrounding or because they would get bored of looking at the screen. So there were several instances when the attention was lost. Therefore having the phone to vibrate was definitely useful in getting the user attention back to the phone screen. From the system logs, we observed that the number of instances of phone vibration would double for a non-attentive user as opposed to an attentive user. We also observed that the face detection system was sensitive to the way the person would hold the phone. For the face detection system to work, the phone had to be held at a particular angle and at a particular distance – with some minor levy. However for the users that we had done the study with, it was difficult to expect them to follow these instructions at all times. Therefore there were a lot of false alerts as well, wherein the phone vibrated even when the user was looking at the phone screen.

CONCLUSIONS AND FUTURE WORK

This paper presented VibRein, which uses rich sensors and interactions on mobile devices to provide a more engaging and effective educational content delivery platform. The paper also highlights the specific user segment of intellectually disabled students that could benefit the most through VibRein. The match of the pain-points of these students with the features of the VibRein system provides a strong proof point of using the rich sensors and features now available on mobile devices. We also believe that VibRein is a timely solution as it builds on the wave of online education and mobile device penetration.

While the described prototype focuses on two specific instances of using the tilt and the vibration to engage with the students, it can be seen that the VibRein system can address a variety of mobile content delivery scenarios using the other sensors present on mobile devices. We therefore believe that VibRein has the potential to effectively use the richer interactions available on mobile devices to provide a more engaging and effective mechanism for educational content delivery for a variety of users in the online education world.

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