Mobile Learning for Farmers via LIVES – Learning through Interactive Voice Educational System

Theme: Social Justice
Sub-theme: Assistive and Affordable Technologies

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1. INTRODUCTION

There are nearly 7 billion people encompassing a vast range of social, political and economic boundaries located in over 200 countries around the world. In many developing nations, the literacy rate is far below developed country standards. The United Nations Development Programme Report summarizes these findings and specifically highlights regions in Africa where the literacy rate drops below 50% (http://hdr.undp.org/en/reports/global/hdr2007-2008/). This presents significant barriers to many traditional forms of learning as many educational materials are delivered through written means, which are unsuitable for an illiterate population. In developing and underdeveloped nations, many people grow up in a subsistence farming lifestyle and never receive the opportunity to attend formal schooling. Moreover, the absence of adequate means of transportation in such communities proves a hindrance to traditional schooling. Consequently, nearly 20% of the world's population lack basic literary skills (CIA 2009).

Thus, as per the understanding of COL (Commonwealth of Learning) and the authors, it made sense then to deliver learning materials through auditory means as this is readily understood by a local population. Instead of reinventing the communication channel, it was decided to use current mobile infrastructure available in developing countries due to the wide use of cellular phones even in remote locations. More importantly an auditory learning channel based on cellular devices would support asynchronous learning since the primary target population of initial users would be farmers who do not have a set time to learn together.

Unlike existing voice-based learning systems that offers simple one-way content delivery to the learners, e.g. via radio or voicemail, LIVES offers two-way communication, anywhere-anytime learning. Aside from acquiring a mobile phone, the learner does not incur any additional costs. The system uses cost-effective Voice over IP (VoIP) technology and open source software for content delivery.

In this paper, we describe the technological aspects of LIVES and its impact on the marginalized communities. This system, based on Asterisk (Digium 2009), an open-source telephony software, can be used to distribute learning content using auditory means in communities with low literacy rates but with good penetration of mobile phones.

1.1. Goals

Based on interacting with COL who support learning in communities with low literacy rates, we have defined goals that an ideal educational approach must strive to accomplish in low-literacy communities.

Personalization: Ability to provide pre-recorded learning material to specific groups of people in specific ways. This specificity should be worked such that the learning methodology can easily morph its behavior to suit each end-user (student, teacher or community) requirements.

Mobility: Students can learn wherever they want without having to travel to a central location to receive instruction.

Asynchronicity: Students should be able to learn at their preferred time of the day, with enough flexibility to fit in their daily schedule. Thus, students should not depend on each other's schedule to learn.

Bidirectionality: Students should be able to provide feedback and answer related questions, receiving instant response based on their input.

Minimal technology investment: To encourage widespread adoption, students should not be required to invest in additional equipment such as special phone devices with multimedia capabilities. A basic cellular phone should be able to meet the student's need.

Progress tracking: Student's feedback and progress should be preserved and gauged to better cater their individual needs, and also to evolve the learning content.

1.2. Contributions

The main contribution of this paper is to provide the design, development and initial experimentation of LIVES. We describe how LIVES makes use of multiple freely available open-source software and mobile infrastructure to meet the learning needs of its target population.

2. RELATED WORK

There are numerous mobile learning projects currently being deployed in developing countries to create equal education and learning opportunities.

The AppLab project (Grameen Foundation 2009) in Uganda provides millions of mobile phone users access to information such as health advice and farming tips. This system leverages the Short Message System (SMS) technology to allow users to send a text message with a keyword to pull out relevant information on a number of subjects related to the keyword. The One Laptop Per Child Association (OLPC), an offshoot of the MIT Media Lab, is designing low-cost devices to supplement traditional forms of education with technology in developing countries learning (Kraemer et al. 2009). A number of projects are based on leveraging open-source based educational systems, such as Moodle (Dougiamas & Taylor 2003). Moodle is an open source e-learning software platform considered as a Virtual Learning Environment. Nokia and the Department of Education and Mindset Network in Africa launched M4Girls project to improve the mathematics performance of Grade 10 female students (Nokia 2009). Smile Communications is testing a service to provide people in Gamalakhe community, near Port Shepstone in KwaZulu-Nata, voice message boxes (Stones 2008).

3. LIVES ARCHITECTURE

LIVES can be broken down into two components. The LMS (Learning Management System) and the LCMS (Learning Content Management System). While the LMS is used to manage and deliver content to the users, the LCMS provides a front-end to create content, students, and course administrators.

Figure 1 shows the different components of the LIVES LMS. The LIVES LMS has been designed using open-source software. The communication server runs Ubuntu Linux with Asterisk PBX software installed. All the students, lessons and questions are stored using a MySQL database (Sun Microsystems 2009a). Both the Call Manager and the Originator modules have been developed using Java (Sun Microsystems 2009b), using Asterisk-Java (Reuter 2009) to connect the modules to a running Asterisk instance.

Communication (PBX) Server

The communication server is based on the open-source software Asterisk. This component is the gateway between the LIVES system and the VoIP technology. It is responsible for establishing and

maintaining the phone calls using VoIP technology, either by contacting a VoIP provider via an Internet connection or using an Asterisk-compliant telephone card to make direct calls.

Call Originator Software

The call originator is a daemon responsible for scheduling and establishing each call. This daemon regularly checks for students that have unheard lessons or unanswered questions, and that are available to receive calls.

Call Manager Server

The call manager deals with the actual interaction with the students. It defines when and how the audio clips (lessons/quizzes) should be played; how the student profile should be stored and updated; how the student will be prompted with options; and how the student's feedback will be recorded.

Database Server and Audio Server

LIVES uses a MySQL database to keep track of the information for each student including time availability, phone number, name and location. It also keeps track of the student's progress based on lessons and quizzes answered. The audio files are also stored in a specific area, which is accessible by the communication server to be played to the student.

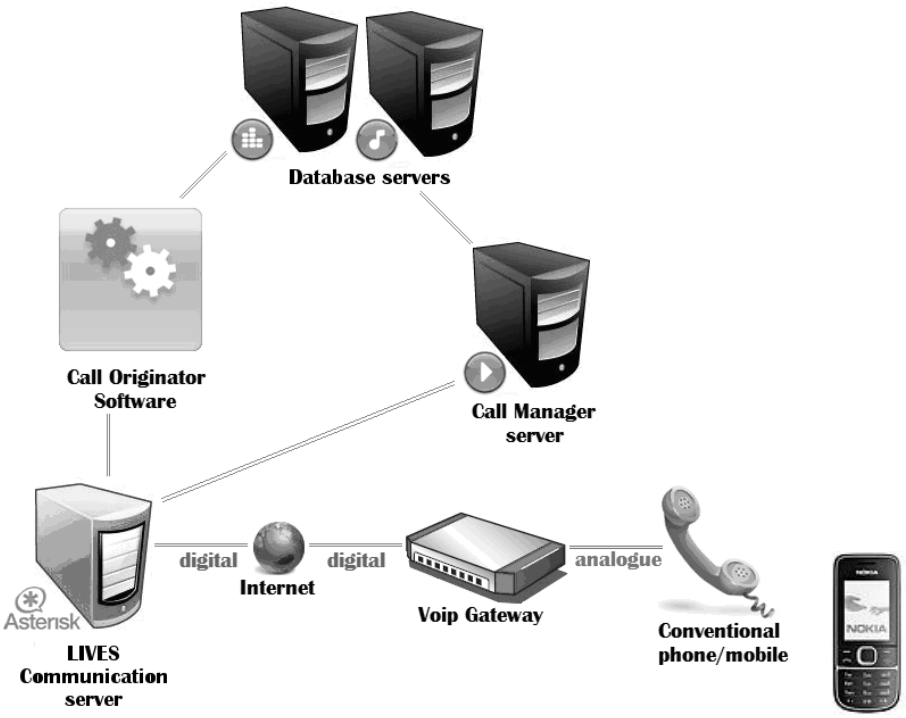

Figure 1: LIVES LMS architecture

The LCMS allows for basic lesson management. This was done by designing the LCMS system based on the open source Drupal (http://www.drupal.org) Content Management System. The LIVES LCMS resides on a separate host which interacts with the database servers of the LMS.

4. LIVES LMS SYSTEM FLOW

1. The call originator accesses the database to check if any lessons or quizzes have been marked as ready. If so, it schedules calls to students based on their available time period.
2. The call originator contacts the communication (PBX) server to make a call to a student when the student time period has been reached.

3. The communication server contacts the VoIP provider and requests a new call to the student's phone number or calling channel.
4. The VoIP provider calls the phone.
5. The student answers the call.
6. The VoIP provider informs the communication server that the call was answered, and establishes a link between the phone and the communication server.
7. The communication server informs the call originator of the status of the call (success/failure).
8. The communication server invokes the call manager server to handle the call, and establishes a link between the phone and the call manager.
9. The call manager interacts with the student to deliver the lessons and questions, and updates the database with the feedback.

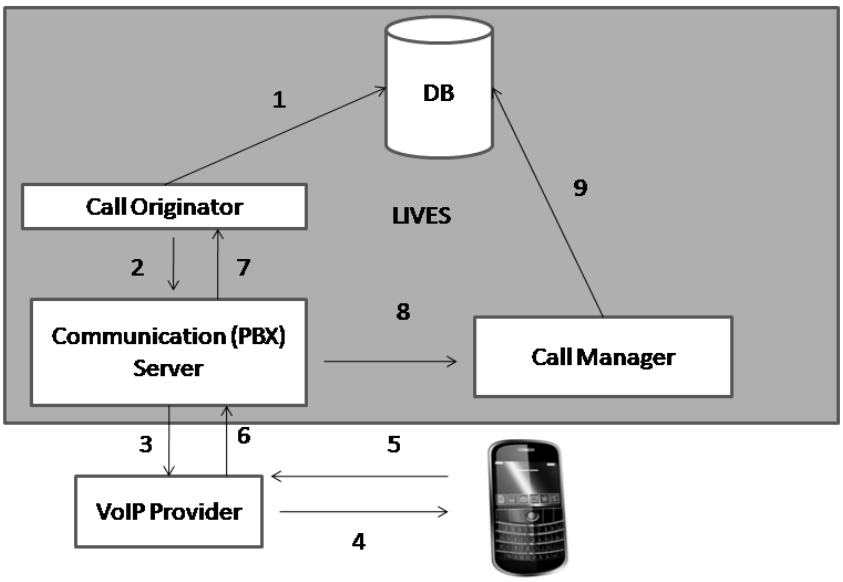

Figure 2: LIVES LMS System Flow

5. IMPLEMENTED FEATURES OF LIVES

This section covers the list of features that have been implemented by the LIVES LCMS and LMS.

LCMS

1) Ability to create students with preferred times to receive calls and assign students to various courses. Each student is also assigned a community that they belong to.
2) Ability to create teachers to administer one or more courses such as adding/editing content, and editing the list of students enrolled in the course they manage.
3) Ability to create lessons and quizzes with keyword tagging, and ability to record content via a web interface. Figure 3 shows the current recording interface used by LIVES.
4) Lessons can be organized by just dragging and dropping available learning units or objects from the right to the current unit on the left. The drag-and-drop feature is enabled by using AJAX (http://www.ajax.org). Figure 4 shows the related interface.
5) Access Control: Access to data is controlled using usernames and passwords, where each user is assigned to specific roles. Each role is assigned specific privileges such as creating lessons, creating content, etc. Creation of roles is done through a Drupal module.
6) The LCMS has the ability to control the list of VOIP gateways to use and the maximum number of simultaneous calls that can be initiated per gateway. This is required for greater scalability, and for conforming to gateway limits that might have been assigned per user account by the VOIP providers.
7) Language support: The system allows administrators to choose the languages they would like to use; assign students to certain languages; and record a piece of content in multiple languages.

8) Multiple question types: i) Multiple choice question; ii) Multiple choice question with no right answer: This allows teachers to gather statistics on which of the available options is chosen by users. For example asking the user on which of the following pesticides are used to treat crops; iii) Question with a numeric feedback as answer: This allows the user to enter numeric values such as price of various goods.

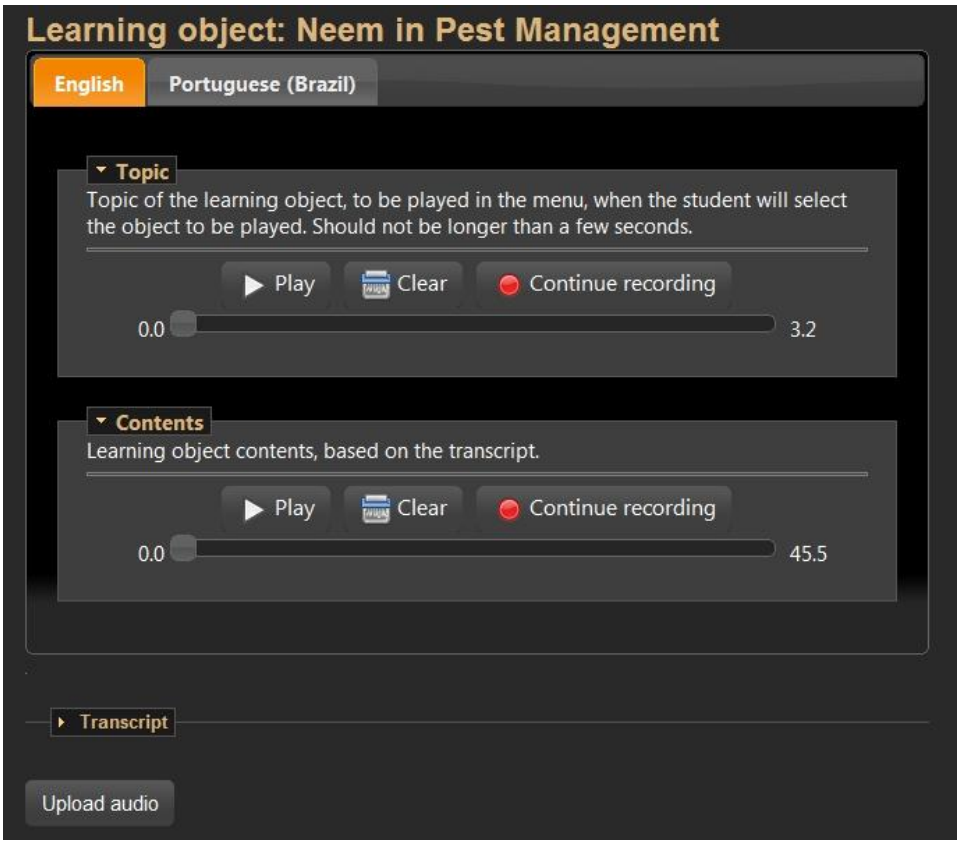

Figure 3: Recording interface of LCMS

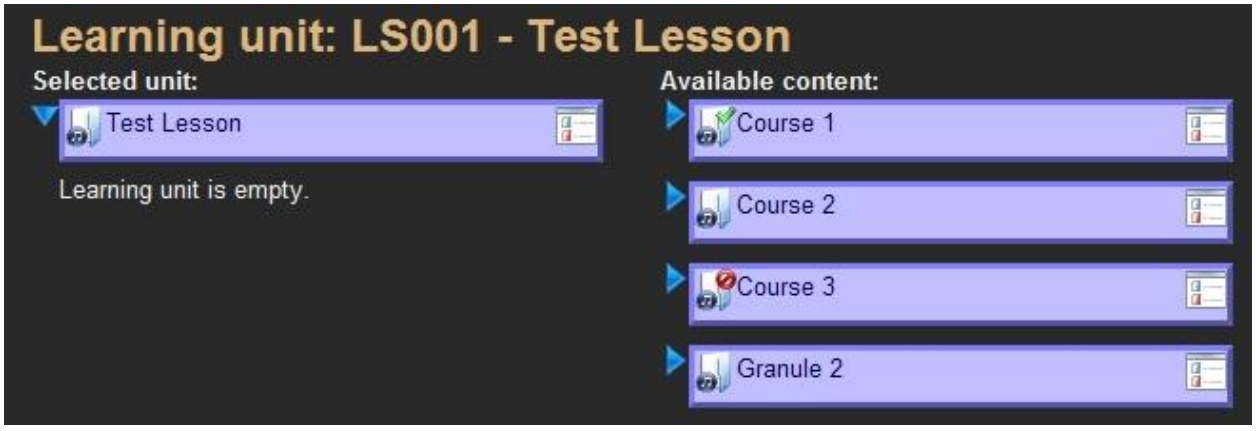

Figure 4: Lesson Organization via drag-and-drop

LMS

1) System calls user (farmer): The users are expected to keep their cell phones turned on during a certain period of time. During that period, the LIVES will initiate a call to the user. The user will listen to the voice message delivered via the call. Typically, the voice message comprises a unit of lesson. In certain cases, the user will be asked to take a multiple choice quiz, possibly following each unit or module of lesson.
2) A student is asked to enter a verification code when the system calls him/her. This is an optional feature that can be used to authenticate a user if required.
3) If a user is requested to take a multiple choice quiz, (s)he will answer the sequence of questions using numeric responses. The system should be able to store and retrieve the responses sent by the user for later evaluation.
4) If the user doesn't pick up the phone, or if the phone is busy, the system will try to call again after a few minutes. This will repeat until the time interval specified to call the user has passed
5) When the user picks up the phone, (s)he will have the option to: a. Listen to the message; b. Indicate that (s)he is not ready to take the lesson. If the user selects the second option, the system will call again in a few minutes. The rules for repeating are the same for busy/not answering.
6) If the user hangs up the phone before completing the quiz, the system will call again in a few minutes.
7) User statistics tracking: The system stores record of all user interactions such as responses to lessons and quizzes, and their associated performances. Figure 5 shows an example statistic.
8) Lesson playback control: The student is able to pause, rewind and forward the lesson based on key presses while hearing a lesson.

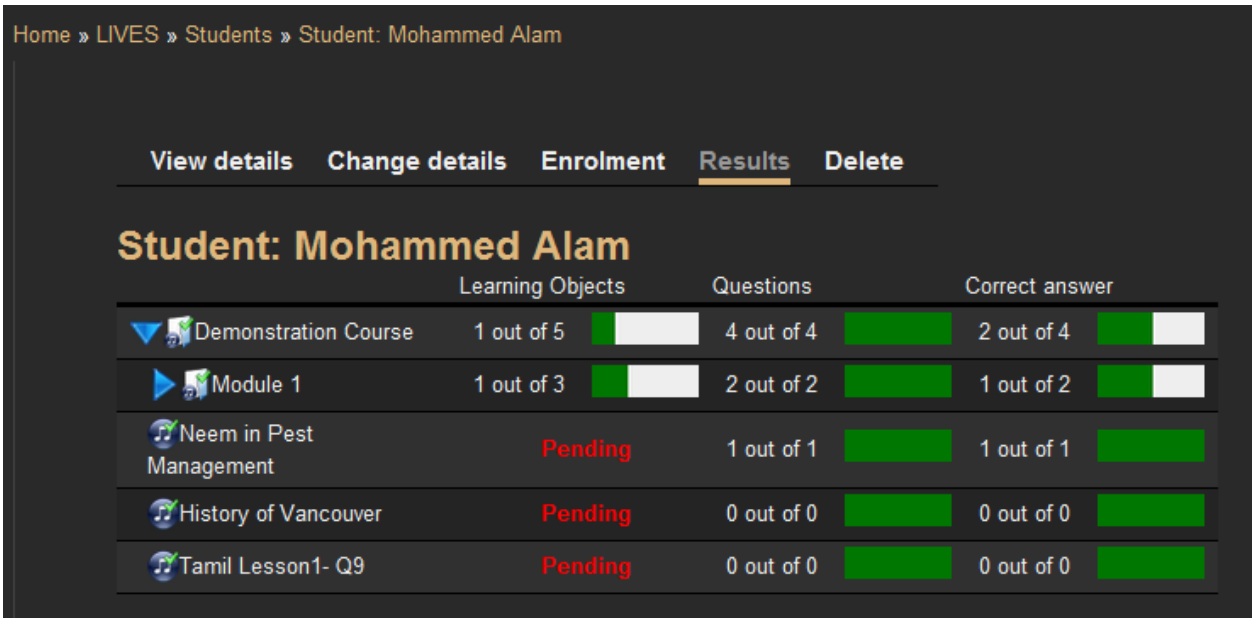

Figure 5: LIVES LCMS student statistics

6. EXPERIMENTATION

This section provides information related to the various stages of testing performed using LIVES.

Stage1: Test 1: Question Testing (with Real users)

This experiment comprised 18 students enrolled in a graduate course at the University of British Columbia (UBC). The students were asked to provide a two hour window during the week when the system would call them. The LIVES system would ask students to answer ten multiple choice questions related to the graduate course they were enrolled in at the time. The students would not be required to listen to a lesson prior to taking the questions.

Once the experiment time frame was complete, the students were asked for their feedback regarding the prototype. This experiment allowed the identification of several goals that would be required in a real environment, mostly in terms of usability and statistical collection of data.

Stage 1: Test 2: Stress Testing (with Real users)

The purpose of this experiment was to stress test the system by calling several students simultaneously, by sending multiple lessons and related questions to students at the same time. This experiment contemplated as students 12 volunteer members in the Commonwealth of Learning (COL). In this experiment, all participants were called simultaneously.

No major issues were encountered during the second set of tests. This was based on the successful completion of most lessons and associated questions by all members, as well as on-site monitoring and questionnaire feedback of users.

Stage 2: Test 1: Performance and scalability investigation (Virtual users)

The LIVES System was installed on a 3GHz Dual Core machine with 2GB RAM. Asterisk servers were installed on two additional 1.86GHz Dual Core machines, which were then configured to function similar to other Gateways, but with calls handled by virtual code rather than directed to physical phones. The LIVES System was then configured to call these servers multiple times simultaneously, with up to 550 active calls at once. Figure 6 shows the setup used.

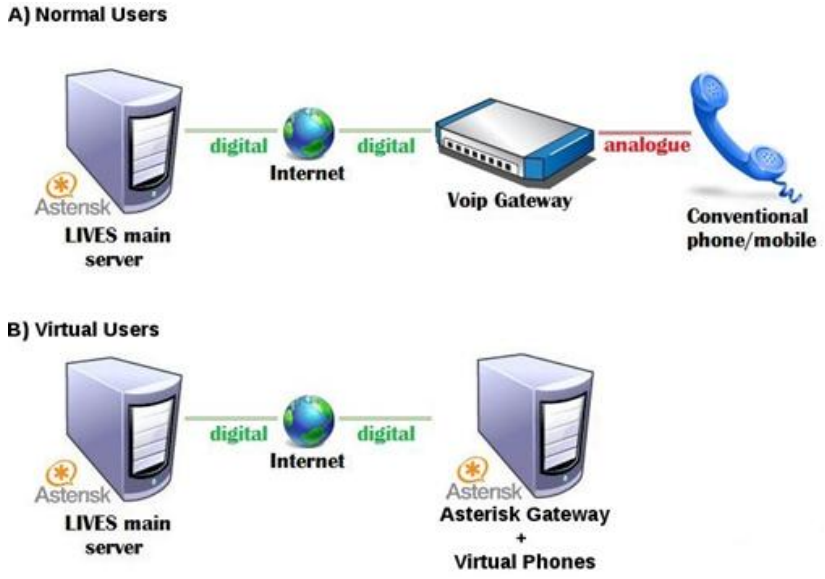

Figure 6: Virtual User setup

The investigation found that there was no observable decrease in the sound quality of individual calls as the number of simultaneous calls increased. It also revealed that the CPU and Memory requirements are actually negligible issues, as even with the full load of 550 concurrent calls, both the CPU% and MEM%

of all the LIVES processes combined were about ~11%. Out of this 11%, majority of the resources were consumed by the Asterisk server, which can actually be installed on a separate computer during the next phase if required.

However, the bandwidth usage can limit the number of concurrent calls, as each active call consumes 7-10 kilobytes (56-80 kilobits)/second of bandwidth. The consumption does not seem to vary significantly regardless of which gateway or phone is called. At the full load of 550 calls, the bandwidth usage is about 4-5 megabytes (32-40 megabits)/second, which can be difficult to achieve in developing countries without appropriate mobile VOIP partners.

Stage 3: Test 1: Beta Testing in India

We are currently in the process of beta-testing with 200 women farmers in India who are part of the L3 (LifeLong Learning) programme of COL. Tests and related feedback are expected to be complete by September 2010.

7. CONCLUSION

In this paper, we presented LIVES, a system based on Asterisk, which is currently deployed for support of mobile learning for communities with low literacy rates. LIVES relies on the use of mobile phone technology for content distribution via voice. The LMS and LCMS components of LIVES is based on open-source software to reduce the cost to enable mobile learning.

8. FUTURE WORK

Based on lessons learned during experimentation and consultation with students, we have identified the following features that could be potentially incorporated into the LIVES system during future phases.

SMS Integration In cases students miss a lesson during their scheduled time, they could send an SMS to the LIVES system to initiate a call by the system.

MMS Integration Quizzes or content using LIVES is not appropriate when they type of information is mathematical in nature, or requires critical thinking such as choosing the right answer based on memorizing multiple variables. This could be solved by integrating a visual queue provided via MMS.

Horizontal collaboration Future versions of this system should be able to allow students to create their own data and share it with other students.

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