Re-orchestration of Remote Teaching Environment in eLearning

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Abstract: eLearning has become indispensable in making lectures from experts accessible to a wide student audience. Current eLearning solutions offer many ways to re-create the teaching environment in a remote location. They focus on recreating the elements that make up the teaching side. In this paper we identify the components of a teaching environment and the factors that constitute a conducive learning environment for students. We identify the common methods of teaching side reconstruction and conduct a study to evaluate the effect of each on the learning outcome on these factors. We analyse the network and computational performance of these methods and arrive at a most optimal method to use in a eLearning session.

1 INTRODUCTION

ELearning has become essential in making quality education reach the masses. Students at remote places can attend live lectures from experts who are at a physically distant place. Moreover, over the years, the process of knowledge delivery by a teacher has transformed and got enriched. Teaching has no longer remained the teacher just lecturing and using plain black board. It now very often includes the teacher using digital content such as presentation, internet based material etc and has impacted eLearning technologies in a multitude of ways (Lau et al., 2014). This had made the task of recreating a realistic immersive experience of knowledge delivery at a remote place complex for live lectures. How effective the eLearning systems are largely depends on how best each system is able to recreate the teachers side, including its multitude of components, in remote places.

We define the components of the teaching side which constitute the content delivered by the teacher as Knowledge Sources. From our observation of many live teaching sessions, the following Knowledge sources were identified to constitute a regular classroom lecture:

- Teaching material - Teaching material used by the professor which is presented on the white board or presentation screen.
- Teachers audio - Teachers speech containing the explanation of the topic
- Teachers video Teachers video gives a feeling of physical presence of the teacher and also is a source of information which consists of the following components: a) Coordinated gestures - Gestures used by the teacher such as hand movement, cursor movement etc which relates the content spoken by the teacher to the teaching material displayed. b) Independent gestures Facial expressions and other gestures used by the teacher spontaneously when he/she speaks to explain a topic.

All these components need to be present to create a complete learning environment. There are multiple ways in which these knowledge sources can be represented digitally for transport to the remote location. This creates multiple media types for the knowledge transport. How these media types can be combined and represented in the remote location gives multiple possibilities for knowledge representation in the remote site.

1.1 Problem Description

The eLearning and video conferencing solutions like A-VIEW, Saba, Skype, Google hangouts etc enable some of the possibilities for teachers side representation. In a simplistic scenario, some systems display video of the teachers part of a class containing the teacher, whiteboard etc. The video from the teachers physical location is compressed and streamed realtime to the remote location. Here, we often see that when the teacher is explaining a concept using a presentation or writing something on the board, the con-

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tent become indiscernible over the video.

To counter this some systems allow uploading the teaching material beforehand for remote students to access or the screencast of the digital content used by the teacher is streamed to the remote location along with teachers audio. In either case when the remote students listen to the teacher lecturing live, in many instances they dont understand which part of the digital content to view in order to follow the teacher.

When both teachers video and the screencast is streamed, these two need to be in synchronization. These components are represented as separate distinct entities in the remote classroom which makes it difficult for the remote students to correlate between the two. When the teacher is pointing at some content on the board while explaining the topic, it becomes distracting for the remote students as they have to first understand the correlation between the teachers video and the teaching content before they can focus on the topic being discussed.

Each of these techniques gives a different experience of the learning environment to the remote students and is effective to different extent. Each technique also differs in cost and performance associated to it in terms of the network bandwidth utilized, latency and complexity of software and the hardware configuration involved. Current research lacks in giving a scientific method to evaluate the learning experience given by these techniques.

1.2 Our Contribution

In this paper, we analyze various factors of a real classrooms knowledge delivery process that needs to be recreated and preserved in an eLearning session for an effective learning experience. We develop a systematic scientific way to evaluate and quantify the effect of each method of recreating the teaching side on the learning experience of the students based on these factors. We start from a most basic method of representation of knowledge sources, evaluate its effects, and proceed towards more complex methods by adding missing factors step by step and finally arrive at an optimal method of representing the teaching components which results in the best learning experienced by the remote students. As we go from simple to complex methods there is also an increase in the cost associated with recreating the multiple media types in terms of network bandwidth and latency. We measure the changes in bandwidth utilization and latency in the system and examine the changes in the complexity of the system. We present the results on both enhancement in the learning experience and the cost incurred due to the increased complexity. As we present these results, we discuss whether the cost and complexity involved in an optimal system is affordable and whether the gain in learning experience justifies the additional complexity and cost of the system.

This work is part of a bigger project NKN (National Knowledge Network) gateway to global classroom, which aims at making the eLearning experience immersive for the students and teachers. The NKN (NKN, 2012) is a multi-gigabit network across India which provides high speed network backbone for connecting Educational institutions across India. We take advantage of this super high speed network for taking eLearning experience to the next level.

The rest of the paper is organised as follows. Section 2 gives an overview of related work. Section 3 describes the experiment design and experimental setup. Section 4 analyses the results of the experiment and Section 5 gives the conclusion.

2 RELATED WORK

ELearning technologies have gained wide popularity because of its capability to give quality education to masses. There has been a lot of study to gauge the effectiveness of eLearning systems. Tanzila Saba, in her paper (Saba, 2012) examines the interconnection between eLearning systems, self-efficacy and the learning outcome for online courses. A case study performed on the blackboard system, a web-based eLearning system (Liaw, 2008) analyses the factors affecting the learning efficiency and found that students self-efficacy, use of multimedia for instruction and interactive modules in the system had a positive outcome on the learning. Studies on blended learning, i.e, blending online media into a course show that it enhances the learning outcomes of the students (Wai and Seng, 2015). MOOC platforms like edX, Udacity, Coursera etc have become hugely popular as a result (Round, 2013). Most of the studies so far have been based on the efficiency of such online courses and evaluating the effectiveness of eLearning systems which act as content provider through various multimedia forms and networking capabilities.

However, a large community of students and teachers use eLearning in its synchronous form where the teaching session is live and there is direct face to face interaction between students and the teacher. This gives the students and teachers a better sense of participation in the classroom session (Hrastinski, 2008).

Video conferencing tools like Skype (Sivula, 2011), Google hangouts (Sean Gallagher, 2013) and Cisco telepresence (Cisco, 2012) offer a ready way for live face to face interaction between students and teacher. Apart from sharing video content for face to face communication, these tools also offer facility to share the screen and thus share any teaching material which is being discussed. There are dedicated eLearning platforms as well like A-VIEW (Lab, 2008), Saba (Saba, 2015) and other similar systems which provide features specific to eLearning in addition to enabling face to face interaction. They enable personal interaction through video and chat, content sharing, screen sharing, students participation with polls and whiteboard activity.

Current research lacks in measuring the effectiveness of such synchronous live eLearning methods. Most of study had been based on measuring the effect of self paced methods on the learning outcomes and the best possible ways to design them. This paper aims to evaluate the learning outcomes and performance of some live synchronous techniques of eLearning.

3 EXPERIMENT DESIGN

The experiments are designed by identifying the most basic way to reconstruct the components of teaching in the remote site, analyze its effect and the missing factors and then upgrading the experiments by designing progressively more complex methods using different combinations and representation of the knowledge sources.

3.1 Representing Knowledge Sources

The knowledge sources of a regular classroom are teaching material, Teachers audio, Teachers video consisting of coordinated gestures and independent gestures. When these sources need to be translated into media types for transport to the remote location, we come across multiple forms of media representations. Some representations include multiple knowledge sources whereas others represent single source. The media type representations are as follows:

- Video of the Environment (V_{Env}) - Video containing the teacher and the teaching material.
- Teachers Video (V_T) Teachers zoomed in video, without the teaching material.
- Screencast (V_{SC}) Video of the activities on the presentation screen containing the teaching material.
- Pointer Video (V_{SC-P}) - Video of the activities on the presentation screen containing the teaching material along with a pointer added to it for indicating the area teacher is focusing on.
- Teachers Audio (A_T) Audio of teachers speech.

3.2 Reconstruction Techniques Representation of the Teachers Side View

The different combinations of the knowledge sources, their representations, relative positioning and size at the remote classroom give rise to different possibilities of recreating the teachers side at the remote site. We start from a most basic representation in our analysis and enrich the representations using multiple media types as follows. In this process, we chose to select those methods which are representative of a real classroom situation and avoided representation such as communication using text chat which are not natural in a real classroom.

- Environment Video - $<V_{Env}, A_T>$. A video stream of the teachers area that includes in its view the teacher, teaching material used in a classroom is displayed in the remote classroom. This forms the most basic representation of the components. Figure 1 depicts the scenario.

Figure 1: Environment Video representation.

- Screencast - $<V_{SC}, A_T>$. Screencast of the digital content used as teaching material by the teacher is streamed and displayed in the remote classroom along with the teachers audio. Figure 2 shows the view seen by the remote students.

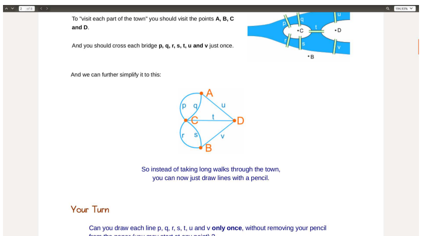

Figure 2: Screencast at the remote classroom.

- Screencast and Teachers video - same screen $<V_{SC}, V_T, A_T>$. Screencast of the digital content used as teaching material by the teacher is streamed and displayed in the remote classroom along with the teachers audio and teachers video on the same screen as the screencast. The teachers video consists of the teacher zoomed in without the full view of the teaching material as shown in Figure 3.

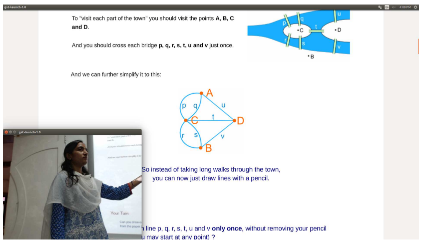

Figure 3: Screencast and Teachers video.

- Screencast and Environment video - separate screen $<V_{SC}, V_{Env}, A_T>$. Screencast of the digital content used as teaching material by the teacher is streamed and displayed in the remote classroom. Along with this the teachers video including the presentation screen content in the background is displayed on a separate screen as shown in Figure 4.

Figure 4: Environment video and Screencast.

- Screencast, Teachers video and a pointer - same screen $<V_{SC-P}, V_T, A_T>$. Screencast of the digital content used as teaching material by the teacher is streamed and displayed in the remote classroom along with the teachers audio and teachers zoomed in video on the same screen as the screencast. Here, whenever the teacher refers to the presentation screen a pointer in the screencast indicates the content area being focused as depicted in Figure 5.

3.3 Experimental Setup

The set up consists of a local classroom, where the teacher is physically present and a remote classroom, where the remote students are attending the lecture live.

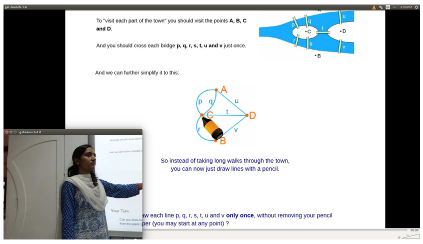

Figure 5: Screencast, pointer and teacher's video.

3.3.1 Hardware Components

- Each classroom included a Logitech C920 HD pro camera connected to a PC (configuration) to capture and stream the video of the participants.
- The local classroom consisted of a Sony 52 inch TV for the teacher to view the remote students and the TVs inbuilt speakers were used for the remote students audio
- The participants were given Shure directional mics to capture their audio and stream though a PC.
- The local classroom consisted of a smart board (Smart Technologies) which the teacher could use as a white board as well as presentation screen. The smart board content were captured and streamed.
- The remote classroom consisted of two Sony 52 inch TVs to display the teacher and other media whenever required.

3.3.2 Software Components

- Gstreamer was used as the streaming solution for video and audio. This was chosen for its speed.
- Smart technologies software for smart board functionalities and touch feature.
- VLC media player was used for streaming the screencast

4 EVALUATION AND ANALYSIS

Based on the knowledge sources representation and the effect each source has on the learning outcome, we arrived at the following factors that contribute towards an effective learning experience. Along with the effect of knowledge sources, we also evaluate how each method influences the interactivity of the students with the teacher:

- *Presence:* Teachers physical presence plays a vital role in engaging the students in the learning process. In addition, it is also a direct source of knowledge when the teacher uses some gestures to convey information.

- *Clarity:* This factor refers to the visual clarity of the information content on the white board or presentation screen.
- *Interaction Alignment:* Refers to the teachers interaction direction, i.e, who the teacher is addressing to while lecturing and whether the students feel the teacher is addressing them.
- *Ease of Interaction:* Ease with which the students and teacher are able to interact with each other. This factor captures whether the students were able to catch the attention of the teacher and talk to him as easily as if the teacher was physically present.
- *Gesture Correlation:* Understanding the correlation between professors gaze, gestures and position with the teaching material focused on.
- *Learning Experience:* This factor summarizes the learning experience based on how well the students were able to focus on the content delivered in the class.

4.1 Learning Experience Evaluation

The reconstruction techniques were evaluated for these factors by conducting a study where each of these techniques were employed and experimented with one by one in a remote classroom and a survey was taken to measure these factors. One topic was taught for each of the reconstruction technique. The topics were chosen such that they are similar in their complexity level and involved using material which had lots of images, equations which are necessary for explanation. The teacher had to often point at the content and the students needed to view the content to understand the topic better. The teaching sessions in each experiment also involved interaction between the remote students and the teacher.

Same teacher taught all the sessions to maintain uniformity in the lecture delivery to avoid any distortions in the result. The remote students were asked to rate each factor on a scale ranging from 0 to 10. Here 0 denoted total absence of the factor and 10 denoted the factor being present as it would in a real classroom to its full extent. Table 1 shows the results.

4.2 Performance Evaluation

The video streams from the local and remote classrooms were sent at a SD resolution of 640x480 at 25 fps. The screencast was streamed at a HD resolution of 1920x1080 (display resolution) at 20 fps. The video streams are encoded using X264 encoder, and the audio stream using mp3 encoder. Corresponding decoding is done at the receiver. Latency in the system is introduced because of the encoding/decoding process and the delay in transmission through the network. The classrooms were connected through 1 Gbps LAN network.

The performance in terms of bandwidth utilization and latency in the system are presented in Table 2.

We observe that the increase in latency is due to HD streaming of the screencast and its associated encoding and decoding. However, the latency was observed to be tolerable by the participants. The improvement achieved in the learning experience because of the usage of screencast overshadowed the slight inconvenience caused by the latency. The bandwidth utilization also did not hamper the performance of the systems. The experiments were conducted over a local area network setup. Over distant places, we propose to utilize the ultra-high speed NKN. This would eliminate the problems arising out of bandwidth requirement to a great extent.

In addition to measuring these factors, subjective analysis of the techniques was done and the discussion on our finding is as follows:

- **Environment Video -** $<V_{Env}, A_T>$ This technique was close to the natural real classroom in terms of the relative positioning and sizes of the knowledge sources and to a certain degree all the knowledge sources were recreated. This technique also fared best in terms of the feeling of presence of the teacher and the ability to interact with the teacher. The main drawback was brought out when we measured the clarity of the digital teaching material. When any digital content is used by the teacher and the remote students view the content through its video, its clarity is degraded to such an extent that in many cases students were not able to follow the topic. This loss in clarity renders this technique unusable in situations where the teacher uses any digital teaching material.
- **Screencast -** $<V_{SC}, A_T>$ To compensate for the loss of clarity in the teaching material, screencast of the digital content was streamed to the remote classroom. A simplistic reconstruction was done where the students view the teaching material and listen to the teachers speech. The teachers physical presence was lost completely and it affected the ease of interaction as well. The students could not relate the audio to its source and found it difficult to interact with the teacher. Also, the students

Table 1: Rating of the factors affecting the learning outcome.

Techniques	Presence	Clarity	Interaction Alignment	Ease of Interaction	Gesture correlation	Learning Experience
$<V_{Env}, A_T>$	7.3	5.33	8.5	9.5	8.33	5
$<V_{SC}, A_T>$	0.66	9.66	1.5	5	0	3.5
$<V_{SC}, V_T, A_T>$	5.33	9.66	6	6.5	6.33	7
$<V_{SC}, V_{Env}, A_T>$	6.33	9.33	6.5	7	7	6.5
$<V_{SC-P}, V_T, A_T>$	5.33	9.66	6	6.5	8	7.5

Table 2: Network performance of the reconstruction techniques.

Techniques	Bandwidth Utilization	Latency
$<V_{Env}, A_T>$	5 Mbps + 77 kbps	250 ms
$<V_{SC}, A_T>$	5 Mbps + 77 kbps	1 s
$<V_{SC}, V_T, A_T>$	7.5 Mbps + 77 kbps	1 s
$<V_{SC}, V_{Env}, A_T>$	7.5 Mbps + 77 kbps	1 s
$<V_{SC-P}, V_T, A_T>$	7.5 Mbps + 77kbps	1 s

were required to put strained efforts in the absence of teachers video and gestures for correlating the teachers speech to the teaching material. Sometimes the teachers audio alone was insufficient to understand where to look at the content on the white board or presentation screen. The teacher had to be stopped for clarifying and made the process of knowledge delivery interrupted with such distracting breaks. In spite of the presence of these difficulties, this method was better usable than the first technique where there was not much scope of understanding the digital content.

- **Screencast and Teachers Video - Same Screen** $<V_{SC}, V_T, A_T>$ The teachers missing presence is included to some extent by adding the teachers video in a corner on the same screen as the screencast. Since the size of the video displayed is very small, the teacher is not seen as clearly as in technique 1 which reduces the feeling of physical presence in comparison. Though the gestures of the professor are seen in the video, the correlation between the gestures and the teaching content cannot be made out easily. This again makes focusing on the content difficult.
- **Screencast and Environment Video - Separate Screen** $<V_{SC}, V_{Env}, A_T>$ To see the teacher clearly including the gestures and its related content, the teachers side video as in technique 1 is displayed along with the screencast on separate screens. This is intended to assist the student in correlating the gestures and the digital content and enhance the teachers presence. However, the survey results show that the students found it very distracting and difficult to follow two screens for the same content. It was very inconvenient to keep switching the gaze between the two screens. Most of the students surveys preferred technique 3 in comparison.
- **Screencast, Teachers Video and a Pointer - Same Screen** $<V_{SC-P}, V_T, A_T>$ To improve upon the students perception of the correlation between teachers gestures and the teaching material, a pointer is used in the screencast. Rest of the representation remains same as in technique 3. Whenever, the teacher points to any content by touching the smart board or uses mouse movement to indicate some region of content, the pointer image appears on the screencast which aids in the students understanding what content to focus on. The teaching delivery becomes easy to follow for the students. The survey results show this technique as the most effective. Even though the teachers presence is felt to a limited extent, this technique results in the best learning experience by the students.

5 CONCLUSIONS

Re-construction of the teachers side in remote classrooms is the most fundamental aspect in eLearning. We have identified the most used techniques for the reconstruction and evaluated each technique for its performance and the learning experience it provides. We started by experimenting with a most basic form of reconstruction where a video of the teachers side is presented to the remote students along with the teachers audio. This required minimal hardware and software setup and had good performance. Though this was the best way to create the teachers presence, it lacked some vital factors for giving a good learning experience to the students. In order to better the students learning experience, we experimented with other techniques to present the teachers side and arrived at a most optimal way for doing so. The technique where the screencast, teachers video and a pointer to correlate teachers gestures and the teaching material were shown in the same screen was evaluated as providing the best learning experience with a rating of 7.5 against 10. This technique fared best when we assessed the clarity and the correlation between teachers gestures and the content presented on screen. There was an increase in the cost with respect to the bandwidth utilized and latency which was however tolerable to a large extent. Our future work will aim at bettering the learning experience of the students by enhancing the naturalness of the recreated environment.

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REFERENCES

Cisco (2012). Cisco telepresence. http://www.cisco.com/c/en/us/products/collaboration-endpoints/immersive-telePresence/index.html. Accessed: 2016-02-16.

Hrastinski, S. (2008). The potential of synchronous communication to enhance participation in online discussions: A case study of two e-learning courses. *Information & Management*, 45(7):499–506.

Lab, A. E.-L. R. (2008). Video conferencing tool, a-view - the versatile e-learning tool. http://aview.in/. Accessed: 2016-02-16.

Lau, R. W., Yen, N. Y., Li, F., and Wah, B. (2014). Recent development in multimedia e-learning technologies. *World Wide Web*, 17(2):189–198.

Liaw, S.-S. (2008). Investigating students perceived satisfaction, behavioral intention, and effectiveness of e-learning: A case study of the blackboard system. *Computers & Education*, 51(2):864–873.

NKN (2012). National knowledge network. http://nkn.in/. Accessed: 2016-02-16.

Round, C. (2013). The best mooc provider: A review of coursera, udacity and edx. *Web. http://www.skilledup.com/blog/the-best-mooc-provider-a-review-of-coursera-udacity-and-edx*.

Saba (2015). Virtual classrooms. http://www.saba.com/us/solutions/virtual-classrooms/. Accessed: 2016-02-16.

Saba, T. (2012). Implications of e-learning systems and self-efficiency on students outcomes: a model approach. *Human-Centric Computing and Information Sciences*, 2(1):1–11.

Sean Gallagher, C. J. (2013). Google beefs up hangouts into text, photo, video chat powerhouse. http://arstechnica.com/information-technology/2013/05/google-beefs-up-hangouts-into-text-photo-video-chat-powerhouse/. Accessed: 2015-12-30.

Sivula, M. (2011). Using skype as an academic tool: Lessons learned.

Wai, C. C. and Seng, E. L. K. (2015). Measuring the effectiveness of blended learning environment: A case study in malaysia. *Education and Information Technologies*, 20(3):429–443.