Effective E-learning Using 3D Virtual Tutors and WebRTC Based Multimedia Chat

Amol Kokane, Hitesh Singhal, Subhayan Mukherjee, G R M Reddy
Department of Information Technology
National Institute of Technology Karnataka,
Surathkal, Mangalore, India
{kokane.amol.t, main.hitesh, subhayan001, profgrmreddy}@gmail.com

***Abstract*—This paper discuss the novel implementation of Learner Centered Design Approach of E-learning System using 3D Virtual Tutors [1] and further enhances this work in facilitating young learners to interact with human tutors using WebRTC Based Multimedia Chat system. The present work adds three main features such as: Firstly, addition of live video lecture session by which students can interact with the tutor just like video call of Skype system. Secondly, the presentation of 3D virtual tutors' narrations of articles in the text form of live transcriptions of avatars' speech. Thirdly, introduction of timed quiz by which a real-life objective examination can be mimicked and thereby evaluating the performance of students. Lastly, we present a comparative evaluation of the original system and its improved version with respect to responses received from a large pool of young learners using the system.**

Keywords-E-learning; Learner Centered Design Approach; 3D Virtual Tutors; WebRTC based Multimedia Chat system

I. INTRODUCTION

E-learning has been referred to as the intentional use of networked information and communications technology in improving the teaching-learning process. E-learning will provide the quality education for everyone using interactive online virtual learning environment. Research [2] has shown that it is better to adopt a leaner centered approach rather than user centered one in designing E-learning systems, as the former caters to the basic needs of motivating learners who are often novices in their work-related activities and try to learn about the same using the system.

Video chat uses live video capture and Internet streaming technologies to facilitate the participants in interacting with each other like face-to-face in real life scenario. There are several existing video chat systems like Skype etc. but these chat systems need additional plug-ins; on the other hand WebRTC system will offer a real-time web-based video chat without plug-ins and it can be further used on any browser without any modifications (Fig. 1).

Some of the existing E-learning systems make use of 2D avatars. Avatar is a graphical character that represents the user in another environment. Fig. 2 shows the screenshot of one of the popular E-learning authoring tools (CourseLab) which offers a programming-free WYSIWYG environment for creating high-quality interactive E-learning content. However, most of E-learning systems including CourseLab do not use 3D avatars as friendly personifications of human tutors to accompany the learners and thus help in achieving

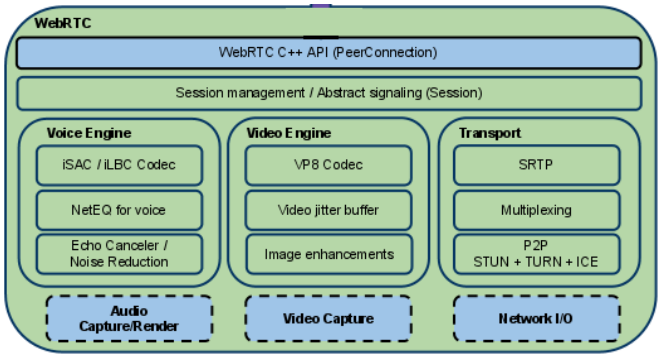

Figure 1. WebRTC: Overall Architecture.

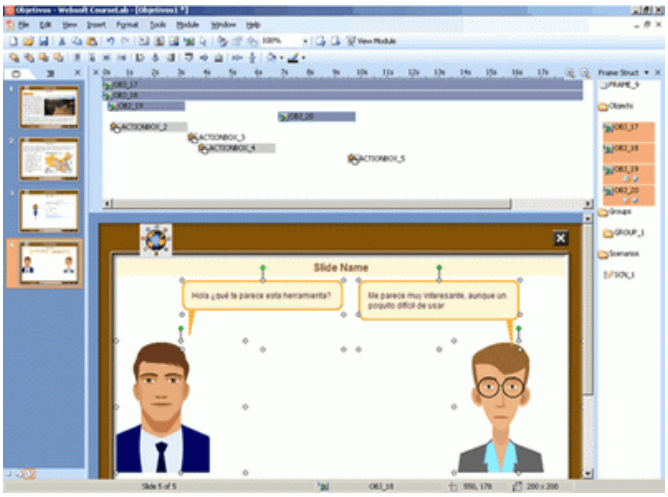

Figure 2. CourseLab: Use of 2D Avatars in E-learning.

978-1-4799-4989-2/14/$31.00 © 2014 IEEE

their learning goals/objectives. We have explored this area by employing 3D virtual tutors.

II. LITERATURE SURVEY

In recent years, several types of E-learning systems have emerged. Because of the fact that nowadays, a wide range of multimedia technologies are available to developers, benefits to the E-learning community come in the form of innovative technological solutions to the challenges of implementing a space-time independent learning environment. The positive effect of such efforts are evident from [3], where the authors have tried to improve the well-known open E-learning system named Chamilo by incorporating three innovative Internet technologies: knowledge search and classification, instant chat system and an online compiler system.

The benefits of interactivity in E-learning for boosting the learners' motivation levels and focus have been emphasized in [4]. Here, authors also stressed upon the importance of low response time in achieving the true interactivity. Hence, it can be inferred that no matter what multimedia technologies we plan to implement in making our proposed system attractive, we need to minimize the overall system response time.

To assess the effectiveness of an E-learning system, there may be several indicators like performance improvement of students in the concerned subjects, referrals to other students for enrolling in the system etc. but a very interesting study has been made in [5], to determine the motivation levels of students during their course of using the system by trying to predict student motivation based on their behavioral patterns on the E-learning platform. Such behaviors include number of hits on the platform to read the course materials, participation in forums to clarify doubts etc.

Some upcoming trends in E-learning have been explored recently including the concept of Collaborative Learning [6] based on students interacting with each other on study-related topics rather than studying entirely on their own. Thus, state-of-the-art E-learning tools should promote an interaction among its learner community through online chat systems, forums etc. Further, a recent study [7] has addressed the question of whether avatars can be used as motivating tools for learners. For the purpose of this investigation, the authors have developed an E-learning system which allows learners to create 2D avatars to represent themselves within the context of the system. The results show that students expressed a moderate, but positive interest in using avatars. So, we took this idea forward by allowing tutors to represent themselves in the virtual world of E-learning in the form of 3D avatars to teach the students the various study topics.

Some existing E-learning systems like Learning Today [1] have three types of logins with appropriate privileges: Admin (for adding, deleting and assigning the students to classes), Student (for reading articles and completing assignments given by faculty and engaging in chat sessions with faculty) and Teacher (for assigning tasks to the students, for engaging in live chat sessions with students for clearing doubts etc.). The Virtual Tutor [2] system has an attractive user interface designed with flash animations for captivating young people. The One Online Learning [3] system presents the concept of on-demand tutoring: one teacher teaches single student or group of students together (parents decide whether their wards should be tutored one-to-one or in a group).

The e-Tutor [4] system provides the flexibility of two types of learning programs to students: Independent program for self-motivated students and Guided program for students who can benefit from guidance by a mentor. The Virtual Tutor Center [5] system presents its users with an online interactive whiteboard: teacher explains a concept to students by drawing diagrams on a virtual whiteboard which is visible and accessible to all students in his or her class. This also is a major help for young learners, who find it easier to grasp demonstrated concepts than abstract ones.

Video chat integration in virtual classroom environments necessitates practical considerations of diverse issues, some of which have been elaborated in [8]. This paper seeks to structure the process for incorporating synchronous video in E-tutoring, by looking at different concern areas, important goals and their associated factors and constraints, and tries to propose qualitative solutions for each. It also presents a novel approach in formalizing the process of delivering synchronous video in an E-tutoring platform consisting of six stages: Environmental Settings, Video Streaming, Video Delivery, Attendance Monitoring, Examination, and User Satisfaction. This paper can serve as a useful guideline for anyone using live video streaming in an E-tutoring context.

We conclude this section with a comparative study of some existing E-learning systems, as shown in Table I. It can be noted here, that in our proposed system, we implemented all of the features listed in Table I, as explained later.

TABLE I. COMPARISON OF EXISTING E-LEARNING SYSTEMS

	Learning Today System	Virtual Tutor System	One Online Learning System	e-Tutor System	Virtual Tutor Center System
3D Tutor	X	X	X	X	X
Web-Search	X	X	X	X	X
Whiteboard	✓	X	X	X	✓
Forum	X	✓	X	✓	✓
Report	✓	X	✓	✓	✓
Video Chat	X	X	✓	✓	X
Text Chat	X	X	✓	✓	✓
Applets	✓	✓	X	X	✓
Quizzes	✓	✓	X	✓	✓
Articles	✓	X	✓	✓	✓

III. METHODOLOGY AND IMPLEMENTATION

A. Improvements over the existing system

Based on our literature survey, some functionalities were identified and implemented in our previous work [1] which could make it effective in motivating young learners. These features are enumerated in Table II for ease of reference. In Table III, we present the new features added to enhance the earlier work, and compare the two in terms of these features.

TABLE II. SALIENT FEATURES OF THE EXISTING SYSTEM

Features	*Description*
3D Virtual Tutors	3D animated characters which can narrate to students summarized versions of the study topics. Young learners typically prefer audio-visual learning modes, and 3D avatars can serve as fun and exciting virtual tutors
Guided & Independent learning modes	Independent learning mode for diligent, self-motivated students who want to engage in self-study at their own pace, without any intervention from a mentor, and Guided leaning mode for those who feel they would benefit from mentoring
Whiteboard	Interactive Whiteboard shared between human tutors and their class through the Internet, using which they can explain concepts by drawing figures using suitable pointing devices
Chat system	Chat system integrated with the virtual classroom using which human tutors can directly interact with students for delivering lecture, answering queries and resolving doubts
Forum	Admin-moderated forum where students can involve in study-related discussions or for resolving doubts, as it has been found to be a very effective learning method for young people. Admin needs to monitor forum to prevent it's misuse
Reports	Reports generated from data on student activity patterns in the system such as studying activity, forum activity and, of course, performance in quizzes conducted by tutors, to serve as feedback to the human tutors from which they can easily gauge student motivation levels and accordingly fine-tune their course contents, study materials and lecture delivery
Applets & Video lectures	Applets and video lectures on study-related topics which can supplement class lectures as audio-visual study media
Web search	Wikipedia and Google search integrated with the system to help students quickly look up any additional material

TABLE III. ENHANCED FEATURES OF PROPOSED SYSTEM

Features	*Existing*	*Enhanced*
3D Virtual Tutors	3D animated characters which can narrate to students summarized versions of the study topics. Entire text spoken by the avatar was being displayed at once, in a static text block which becomes monotonous	Online transcription of text articles spoken by avatars; words of the article appear on the screen dynamically as and when the avatar speaks them
Chat system	Chat system integrated with the virtual classroom using which human tutors can directly interact with students for delivering lecture, answering queries and resolving doubts. Existing system has only text chat, which does not mimic the real-world scenario of tutors and their class interacting face-to-face in a physical classroom environment	Video chat integrated with the existing text based chat system by which faculty and his or her students can interact, just like Skype
Quiz module	Untimed quizzes which do not faithfully mimic a time-bound real-world examination	Time limits on quizzes to better evaluate the students' progress

[1] http://www.learningtoday.com
[2] http://virtualtutor.net
[3] http://oneonlinelearning.com
[4] http://e-tutor.com

B. System Architecture and Use Cases

Fig. 3 shows the system architecture diagram of the new system with the changes highlighted in the 3D Virtual Tutor, Quiz and Chat system modules. No significant changes have been made, however, to the workflow of the system, but for the sake of completeness, we present the same as algorithms.

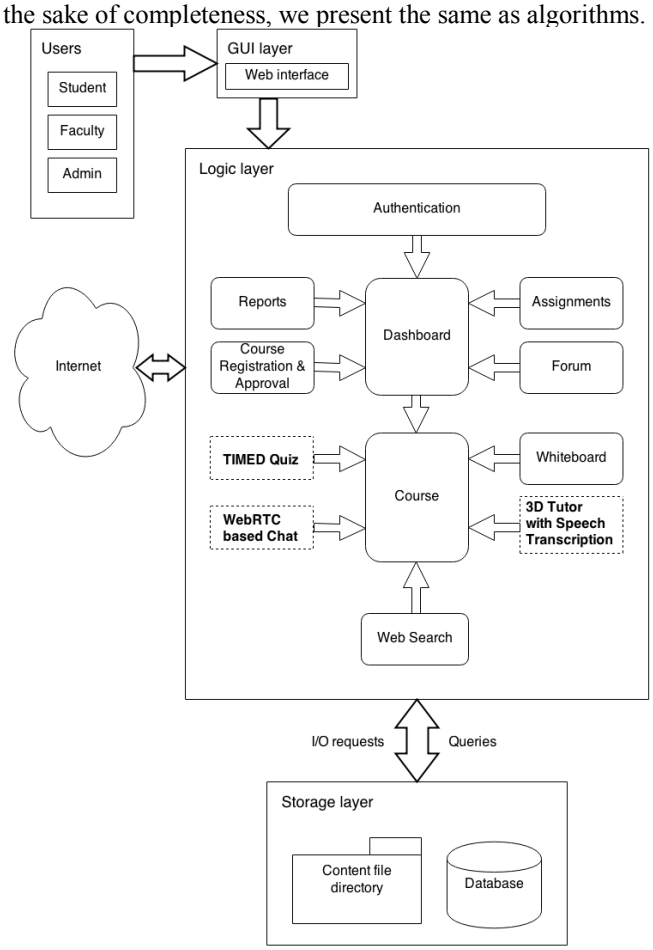

Figure 3. Enhanced System Architecture Diagram.

Algorithm 1 Student Activity Module

1: **Register** and **Logon** to the system
2: **Perform** any of the following activities
3: **Register** and **Take** courses using any of the following activities
4: **Take** courses in unguided mode using 3D tutor and study materials
5: **Take** courses in guided mode using live chat sessions with faculty
6: **Discuss** doubts with other students and faculty using the forums
7: **Solve** and **Submit** assignments uploaded by faculty
8: **Take** quizzes on already completed courses to assess own progress

Algorithm 2 Faculty Activity Module

1: **Register** and **Logon** to the system
2: **Perform** any of the following activities
3: **Register** and **Teach** courses using any of the following activities
4: **Teach** in unguided mode; create 3D tutor animations & study-mats
5: **Teach** in guided mode; host live chat sessions with students
6: **Approve** course registration requests sent by students to him / her
7: **Upload** assignments to evaluate his / her students' progress
8: **Assess** students' progress from reports on student-system interactions

[5] http://www.virtualtutorcenter.com

Algorithm 3 Administrator Activity Module

1: **Logon** to the system
2: **Perform** any of the following activities
3: **Approve** students' and faculties' registration requests
4: **Assign** faculty to teach courses
5: **Moderate** forum posts to prevent its possible misuse

C. *Implementation*

We have implemented this enhanced E-learning system architecture for the student, faculty and admin using JSP, Servlet, AJAX, HTML, CSS and Oracle database. The user interface has been enhanced through special effects on UI elements, including the word-by-word live transcription of the avatars' speech, using JQuery. The 3D avatar animations have been prepared by the same process mentioned in [1]. For video chat, the available advanced and versatile WebRTC API is used [9]. WebRTC based multimedia chat system API has been developed by Google so as to facilitate the users to communicate with each other without the need of any plugin installed at either of the machine. The implementation of WebRTC includes writing several javascripts for each audio, video, one to many video/audio and for several other features provided by WebRTC. The main advantage of using WebRTC is the handling of privacy issues of the users. The WebRTC API, embedded in the browser handles all the issues and most web browsers support it, so browser is not a setback in case of WebRTC.

Fig. 4 shows the implementation diagram of the proposed system with respect to which components of our system are hosted on our own server and which ones are executed from third-party servers (e.g., Sitepal.com, which hosts all the 3D avatar animations).

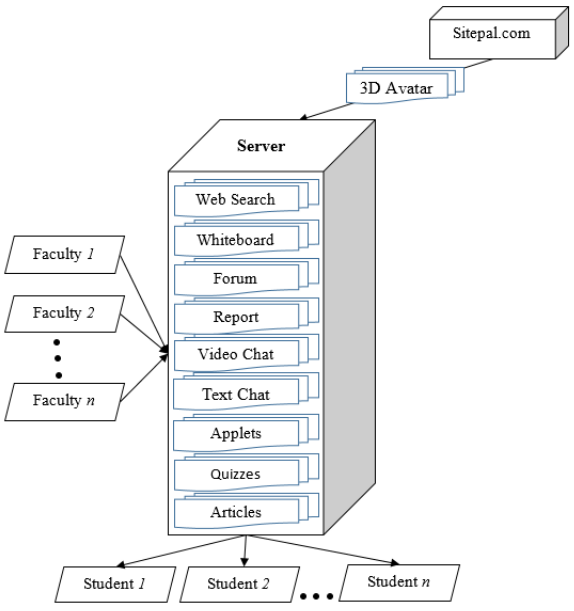

Figure 4. Implementation Diagram of Proposed System.

D. *Evaluation of system effectiveness*

To compare our prior and present work, we designed a questionnaire having ten questions which try to elicit the opinions of the young learners using the system, on the effectiveness of various features of our work, on a five-point scale, as in Table IV and Table V. We then circulated the questionnaire among the students of our institute who are users of the system, and recorded their anonymous responses using the free-to-use Google online feedback collection and analytics service. We present the results in the next section.

IV. RESULTS AND DISCUSSION

Table VI lists changes made to the modules in the new system in agreement with the enhanced architecture. Fig. 5 and Fig. 6 present screen shots from the new implemented project to give a glimpse of the changes made to the 3D tutor module showing the word-by-word speech transcription and Chat system showing the WebRTC-based video chat feature.

Lastly, we present results of our survey conducted using the questionnaire described in the previous section, to judge the effectiveness of the features of the existing and enhanced system in motivating young learners, using bar charts which depict the frequencies of user responses for various opinions (O1–O10), using the five-point scale, as shown in Fig. 7.

Hence, it can be clearly observed that the results of our survey demonstrate the effectiveness of our system, and how it has been improved with the addition of the new features.

TABLE IV. QUESTIONNAIRE FOR FEEDBACK COLLECTION

Opinion No.	***Opinion***
O1	I feel that the E-learning system Without video chat is enough to motivate young learners.
O2	I feel that adding the Video chat feature between students and tutors in the E-learning system provides extra motivation to young learners.
O3	I feel that the E-learning system is more Focused towards young learners than elderly people.
O4	I feel that young learners using the E-learning system find it easier to understand difficult concepts by referring to the Supplementary materials like video lectures, interactive applets etc.
O5	I feel that collection of the E-learning system usage Statistics of students, like their frequency of forum activity, quiz scores or engagement in similar other study related activities can help tutors estimate the students' motivation levels.
O6	I feel that giving students the option of Independent (self-study) or Guided (tutored) learning modes in the E-learning system is essential to their learning success, because each student has his or her own learning style.
O7	I feel that the presence of 3D avatars as virtual tutors, along with effective study materials in the E-learning system increases the young learners' motivation levels by making the teaching-learning process fun and exciting for them.
O8	I feel that the live 3D avatar speech transcription feature of the E-learning system is a good way to engage young learners in the self-study mode.
O9	I feel that young learners can learn better by using the discussion Forums of the E-learning system to help each other understand difficult study topics and develop effective learning strategies.
O10	I feel that the shared, interactive Whiteboard of the E-learning system is a great teaching aid for the tutors to explain difficult concepts to his or her class by drawing suitable diagrams.

TABLE V. DESCRIPTION OF THE FIVE-POINT SCALE USED

Point	*Meaning*
1	Strongly disagree
2	Disagree
3	Neither agree, nor disagree
4	Agree
5	Strongly agree

TABLE VI. CHANGES MADE IN THE PROPOSED SYSTEM

Modules	*Functions*
3D Virtual Tutors	Live speech transcription, resulting in text articles not visible at once as a static block of text, but rather, dynamically, word-by-word in accordance with the avatars' speech to make it lively
Chat system	Skype-like video chat has been made possible using the open-source WebRTC project
Quiz module	Time-bound quizzing has been introduced to mimic real-world examination scenarios

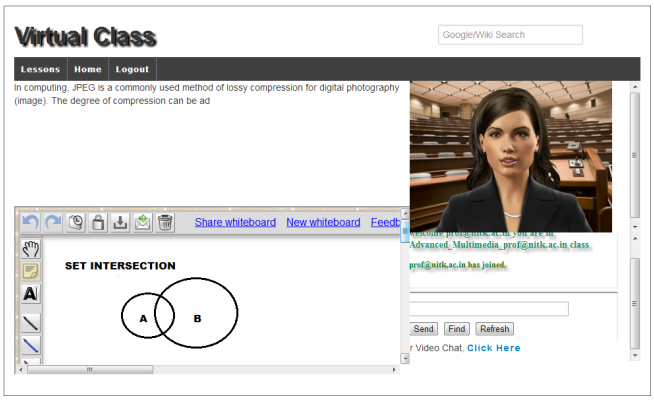

Figure 5. Virtual Classroom.

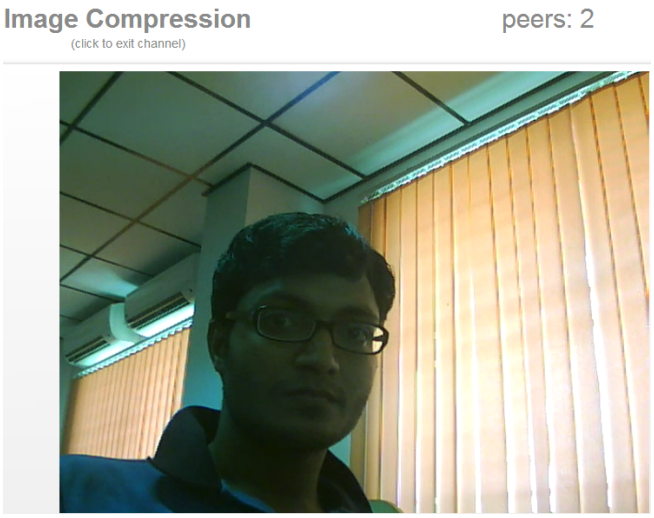

Figure 6. Video Lecture Session using WebRTC.

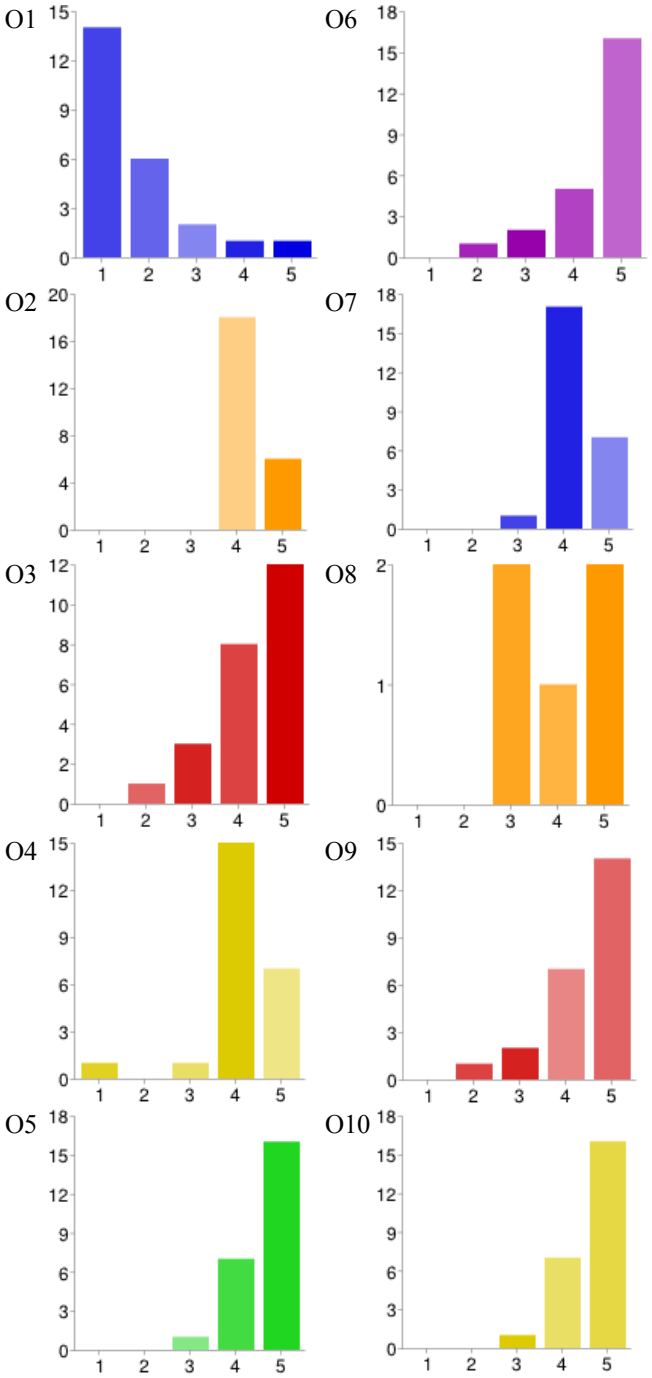

Figure 7. Bar charts showing the frequencies of responses received from users of our system on the various opinions (O1–O10), with the five-point scale along the horizontal axes and the frequencies along the vertical axes.

V. CONCLUSION AND FUTURE WORK

In this paper, we have tried to improve upon our previous work which proposed a LCD-based E-learning framework as opposed to the much-used UCD. As part of this work, we have added WebRTC-based video chat, avatar speech-to-text transcription and timed quizzes. We have also come up with a comparative evaluation of the prior and present work by

conducting questionnaire-based surveys among young learners who are using our system. Possible future works are:

Simulating virtual classrooms consisting of 3D avatar representations of both human tutors and students and their mutual interactions through instant chat between the avatars.

Generating more fine-grained reports on the statistics of system usage and performance of students and faculty, which can help the administrator to identify efficient tutors.

VI. ACKNOWLEDGMENTS

The authors would like to thank Prashant Jha, Priyank Rastogi, Ravi Mittal, Ashika P Shivam and Pooja H B of the Information Technology department of the National Institute of Technology Karnataka, Surathkal, India for their valuable technological contributions and active support to this project.

REFERENCES

[1] S. Mukherjee et al., "Learner Centered Design Approach for E-learning Using 3D Virtual Tutors," Technology for Education (T4E), 2013 IEEE Fifth International Conference on, IEEE Press, Dec. 2013, pp. 133-134, doi: 10.1109/T4E.2013.39.

[2] D. Dhar and P. Yammiyavar, "Design Approach for E-learning Systems: Should it be User Centered or Learner Centered," Technology for Education (T4E), 2012 IEEE Fourth International Conference on, IEEE Press, July. 2012, pp. 239-240, doi: 10.1109/T4E.2012.57.

[3] Q. Li, C.Y.K. Lin, H. Chang and C. Wang, "Application of innovative technologies on the E-learning system," Computer Science & Education (ICCSE), 2011 6th International Conference on, IEEE Press, Aug. 2011, pp. 1033-1036, doi: 10.1109/ICCSE.2011.6028812.

[4] M.G. Awad, N.B. Hani, F. Al-Kalani and R. Sahawneh, "Web design: Optimizing model for designing E-learning web site," CAD Systems in Microelectronics (CADSM), 2011 11th International Conference The Experience of Designing and Application of, IEEE Press, Feb. 2011, pp. 294-297.

[5] M. Munoz-Organero, P.J. Munoz-Merino and C.D. Kloos, "Student Behavior and Interaction Patterns With an LMS as Motivation Predictors in E-learning Settings," Education, IEEE Transactions on, vol. 53, pp. 463–470, August 2010, doi: 10.1109/TE.2009.2027433.

[6] K.S. Kumaran and V.S. Nair, "Future trends in E-learning", 2010 4th International Conference on Distance Learning and Education (ICDLE), IEEE Press, Oct. 2010, pp. 170-173, doi: 10.1109/ICDLE.2010.5606011.

[7] M.N.A. Mazlan and L. Burd, "Does an avatar motivate?," Frontiers in Education Conference (FIE), 2011, IEEE Press, Oct. 2011, pp. T4J-1 - T4J-6, doi: 10.1109/FIE.2011.6142700.

[8] A. Vakaloudis, A. Mouhtaropoulos and C.S. Chilas, "Evaluating the incorporation of synchronous video services in eLearning applications," e-Learning and e-Technologies in Education (ICEEE), 2012 International Conference on, IEEE Press, Sep. 2012, pp. 89 - 94, doi: 10.1109/ICeLeTE.2012.6333381.

[9] Bertin, E.; Cubaud, S.; Tuffin, S.; Crespi, N.; Beltran, V., "WebRTC, the day after: What's next for conversational services?," Intelligence in Next Generation Networks (ICIN), 2013 17th International Conference on , vol., no., pp.46,52, 15-16 Oct. 2013, doi: 10.1109/ICIN.2013.6670893.