# **Envisioning the Transformative Role of IT in Lectures**

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**Abstract.** One of the most widely used methods for teaching is the lecture. During the last few decades lecturers and students have taken advantage of the progressive introduction of new technology for supporting these lectures. As this trend is very likely to continue, in this paper we will try to anticipate some possible technology enriched future lecture scenarios. We also present ALFs, a system which aims to improve the communication between participants in a lecture making use of augmented reality techniques.

Keywords: Lecture, Augmented Reality, Classroom Response System

### **1** Introduction

Lectures have been the subject of some controversy during the last few decades. Among the most prominent criticisms levelled against this teaching method is that it has shown itself not to be as effective in promoting thought as the discussion teaching method, and that there is neither significant evidence of it being more effective in transmitting facts and information than other teaching methods such as reading, discussion or projects [1]. On the other hand, it has been argued that lectures are not only especially suitable for some specific areas and educational circumstances, such as communicating conceptual knowledge or presenting up to date information, but they also have intrinsic motivational values apart from their cognitive content [2]. Furthermore, lectures offer a significant advantage over other teaching methods, which lies in the fact that the lecturer can bring into the lecture his/her own critical perspective on the subject, helping students transform and construct knowledge [3].

Despite the criticism received, lecturing is still one of the most widely used teaching methods and one of the oldest. Typically, during a lecture the lecturer stands in front of an audience and makes use of his/her oratory and communication skills by explaining concepts and providing examples in order to facilitate the learning on a particular subject. A lecture is therefore chiefly an oral speech where success strongly depends on the ability to successfully communicate with students [4]. However, the lecturing method has evolved over time, and lectures nowadays have little in common with the original lectures carried out during the medieval time. Looking back before the introduction of the printing press, the lecture consisted mainly of reading a text to an audience, followed by some kind of critical analysis provided by the teacher. With the proliferation of books, lecturers progressively stopped reading texts and increasingly concentrated on the latter, critical part, explaining a subject in such a way as to orientate and facilitate students' comprehension. Nowadays, modern lectures

have enriched the traditional lecture method both from a pedagogical perspective, with the introduction of different techniques for fostering active learning in the classroom, and from a technological one, through the use of different technological advances and the integration in the lecture of audio, image, video, etc. resources.

Given recent technological developments, it is almost certain that lectures will continue to evolve, overcoming present limitations and enriching the experience by taking advantage of the possibilities that new technology offers. In this paper we will envision how technology may further transform the lecture scenario in the near future, improving the multidirectional communication flow established during a lecture, especially from lecturer to student and from student to lecturer, in both face-to-face and distance lectures. We also propose a system which aims to improve the communication between lecture participants by making use of augmented reality (AR) technology. Finally, we discuss some of the possible benefits and limitations of the system, and present some conclusions.

## 2 Patterns of Communication in Lectures

In this section we will analyze how different technologies may affect and improve the communication flow established during a lecture from lecturer to student, and from student to lecturer, and how they may also improve the support for distance lectures.

#### 2.1 Teacher to Student Communication Flow

During scheduled time allotted, the lecturer usually explains concepts, provides examples and may even try to foster more active learning, motivating students by questioning them and proposing exercises. Although the lecturer's main instrument is his/her communicational skills, very frequently they make use of some kind of support to outline the lecture contents and to facilitate explanations. For many years this support has taken the form of a large whiteboard in most settings, although during the latter part of the past century we have witnessed the progressive introduction of audio, images, video resources and Internet connection in classrooms, allowing access to a vast amount and variety of resources which were previously unavailable. Interactive whiteboards are also gaining increasing popularity as they provide an intuitive way of handling that information, and allow the recording of annotations spontaneously.

When imagining a future lecture scenario, it is very difficult to think that the lecturer's pedagogical skills and his/her ability to communicate could be replaced by any other means. However, it is very likely that the instruments the teacher uses for supporting his/her explanation continue their evolution, taking advantage of the latest advances in technology as well as the computer literacy of her students. The characteristics of the so called "digital natives" will demand new teaching strategies that benefit from their capacity to deal with multiple streams of information and from their visual literacy skills [5]. For instance, a logical step after the introduction of video in the classroom could be the use of 3D representations. These representations could be provided by 3D screens, holograms generator systems [6] or AR devices [7], for instance, and could be of great help when explaining subjects which involve concepts of a spatial nature such as architecture, geometry [8], etc.

#### 2.2 Students to teacher communication flow

It is very likely that during a lecture the teacher will interrupt her explanation to allow students to raise doubts and comments, to question them or to propose short exercises. These techniques not only promote active learning and serve to engage students in the lecture, but also make it possible to obtain feedback about students' actual learning. Even in lectures in which the teacher speaks continuously and does not make use of these techniques, he o she might gather feedback on students' learning from their expression and reactions to the speech. Based on the feedback obtained, the lecturer may, for example, adapt the lecture spontaneously, modifying the pace of the lesson, providing extra examples or repeating explanations of concepts presented in previous lectures. This way he or she ensures that the majority of students attain the learning objectives in that particular session.

However, it is not always easy to collect the required evidence on students learning. Sometimes students are shy and feel reluctant to share their opinions or communicate their difficulties when understanding a concept or following the lesson. The problem is greater in large lecture classrooms in which participation is very often reduced to a small group of enthusiastic students. This scenario can be alleviated by the use of Classroom Response Systems (CRSs) [9], which allow the anonymous and immediate collection of responses from the students. This way, making use of PCs, tabletops or specific devices [9], students can respond to the questions posed by the teacher, who can instantly access histograms showing the distribution of the answers of the class. The use of mobile technology as a way of implementing these systems is becoming increasingly popular as it helps to reduce the cost of the system [10], [11].

The feedback loop between students and lecturer could be improved if the lecturer is provided with a system which allows the information to be managed and gathered from a CRSs system in a natural and instant way, without interrupting the flow of the lecture. In this sense, AR technology could offer interesting possibilities, as it could allow students to display visual cues that the lecturer would be able to see when focusing an AR device on them. This way, the students will be provided with a communication channel hitherto unavailable to them which would allow them to communicate with the lecturer without fellow students even noticing.

#### 2.3 Distance Lecture Support

Current communication capabilities allow us to overcome the traditional restrictions of time and space, associated with traditional lectures. By installing video cameras in the classroom and using a videoconferencing system it is possible to follow a lecture despite being placed in another location [12]. Another possibility to overcome these limitations is to arrange the lecture in a 3D virtual world, in which students and lecturer will be represented through their avatars [13], [14]. Although this option increases the sensation of presence of students, it also has the drawback that non-verbal communication of the lecture is severally reduced [15]. On the other hand, managing the student feedback through a videoconferencing system could become difficult for the lecturer as the number of students increases.

It is expected however that future distance lectures could overcome these problems. With regards of the lecturer-student communication in distance lectures, some of the latest advances in computer-interaction devices, as Microsoft Kinetic [16] for instance, could facilitate the capture of the lecturer's body language and its direct translation into avatar gestures. Facial expression recognition algorithms could also be applied to translate lecturer expressions into her avatar [17], [18], although a more simple possibility could consider embedding video streaming of the lecturer into screens placed in the virtual world. With regards to student-lecturer communication, providing the virtual world's lecturers with a large touch-interactive display could facilitate managing students' feedback. On the one hand the use of touch gestures will simplify the interaction with the system, which should be as unintrusive and intuitive as possible in order to be carried out during the lecture. On the other hand the display would act as a window to the virtual world and it will replicate the distribution of a traditional classroom environment in which the lecturer speaks standing up in front of rows of seated students. A more sophisticated scenario could consider the integration of AR representations of the avatars of the students in a real classroom environment, in a similar way to the videoconferencing experiences described in [19], [20]. This way the lecture could be given to both students physically present as well as distance students without impeding any of the communication flows.

## **3 Augmented Lecture Feedback System (ALFs)**

As explained in the previous section, some of the recent technological advances appear to offer appealing possibilities for lecturing. However, their integration into a real classroom setting is likely to bring a number of practical problems to light. With the aim of exploring the benefits and anticipate the problems and limitations, we carried out the design of ALFs, an Augmented Lecture Feedback System (ALFs) which aims to improve the communication between participants in a lecture. More specifically, the system makes use of AR techniques to make an additional channel available to students, which would allow them to communicate with the teacher in an instantaneous, rich and private way.

### 3.1 System Architecture

Figure 1 depicts the general architecture of the ALF system. As shown in the diagram, the system architecture is composed of three different layers: knowledge modeling, communication and representation. The first layer supports the lecturer in describing the lecture plan and the information he or she aims to elicit from the students during the lecture. The second layer provides students with the means to provide the lecturer that information. Finally, the third layer allows the lecturer to see AR representations of the feedback provided by the students. The left and right hand side of the pictures depict two different implementations of this layer for face to face and distance lectures, respectively. Each of the layers is described in detail in the following sections.



Fig. 1. General architecture of the ALF system.

#### 3.1.1 Knowledge Modeling Layer

The knowledge modeling layer contains models which, on the one hand, describe the concepts, activities and material which compose the lessons and the course, and on the other hand, the profile and actual knowledge of the students and the knowledge of the classroom as a whole (Fig 2). These models have been derived from the ones used in Web-based Adaptive and Intelligent Educational Systems (AIES) [21], but instead of supporting the automatic adaptation of a course, they will be used to support the lecturer in adapting the lecture in a natural, and spontaneous way. Before the lecture starts, the teacher will specify the model of the lecture by outlining the sequence of explanations, examples, exercises or question rounds he or she aims to follow (models in the left hand side of Fig 2). During the lecture, each student will feed his/her corresponding knowledge model by providing personal estimation of the knowledge gained for each of the concepts tackled by the lecture activities (models in the middle of Fig 2). In addition assessed knowledge models and inferred knowledge models can also be maintained. The former will be fed with the results of formative and summative evaluation activities, as exercises or test, and it will allow comparing those results with the current knowledge estimations provided by the learner. The latter will make use of the student's background information and the knowledge assessed for other related concepts for providing the lecturer an estimation of the student's knowledge on those concepts for which no entries have been provided so far. Finally, it would also be interesting to maintain models which represent the average knowledge of the students in a group (models in the right hand side of Fig 2). This could help to identify which students have already understood a concept/idea compared to those who need further assistance.



Fig. 2. Models of the knowledge modeling layer.

#### 3.1.2 Communication Layer

The update of the models by the students is supported by the communication layer of the system, which could be implemented by making use of an existing CRS or, alternatively, just a web application made available through mobiles and PCs. This way, as the teacher progresses through the lecture, s/he will use the system to select from the previously specified sequence of lecture activities the one which is about to start. The students' view of the system is then updated so they can begin to introduce their comprehension estimation on the concepts tackled by the current explanation or activity, updating the corresponding knowledge model. In addition, in the case of lecture activities as exercises or question rounds, students will also be able to communicate their current status in relation with the activity to the lecturer by choosing from a set of pre-defined ones such as, "just started", "finished", "I know the answer", "I don't know what to do", etc. Finally, students will also be able to display some general status related to common situations that might take place during the lecture for example, "Please, slow down the explanation", "I would like to ask a question in private", etc.

#### 3.1.3 Representation Layer

Finally, the representation layer provides the lecturer with immediate and private access to the information gathered in the knowledge modeling layer about each student at every moment of the lecture. The system transforms the information the lecturer aims to obtain into graphical representations that he/she could easily interpret. These representations are overlapped on the lecturer's view, at an suitable size and position to help him/her identify which student each representation refers to. This way, access to

the students' information is provided in a private way, as students' views are not augmented and therefore they cannot visualize the same representations as the lecturer.

The technique used to augment the reality of the lecture will be different depending on whether the lecture is being carried out in a face to face or distance modality. In the case of the former it will be necessary to provide the lecturer with an AR device. The device will be able to identify and process a visual symbol that the student would be required to place in a visible place next to him/her. As depicted on the left in figure 1, by focusing the device on students' symbols and adjusting different parameters, the lecturer will be able to see computer-generated representations of the status of the student concerning the last explanation or activity, information from his or her profile such as name, current values of their concept comprehension estimations, etc. through the visor.

In the case of distance learning lectures the technique used will depend on the means provided for supporting the lecture. On the right in Fig 1 the implementation proposed for augmenting distance lectures supported by virtual worlds is depicted. As shown in the picture, the augmented symbols that represent the students' current status and level of knowledge are directly shown in the virtual world, each one positioned close to the corresponding student's avatar and transparent to all but the lecturer. In order to minimize the loss of non-verbal communication, the representation of the lecturer is also augmented. This way, the lecturer not only is represented in the virtual world by his/her avatar, but the virtual classroom also includes streaming video of his/her speech. Furthermore, a movement capture camera allows for the recognition of some specific lecturer movements, such as pointing to the presentation or to the students, and to trigger associated predefined animations of the lecturer's avatar. Finally, the lecturer will carry out the lecture using an interactive whiteboard, which will allow him/her to visualize both the view of the virtual world and a view in which the resources used for supporting the explanations are presented at the same time. Furthermore, the use of the whiteboard simplifies the interaction with both views just by the use of simple touch gestures.

#### **3.2 System Implementation**

With the aim of evaluating the benefits and limitations of the proposed approach we are currently working on an implementation of an ALF system prototype for supporting face to face lectures. The prototype makes use of a web application for implementing the functionalities related with the first two layers of the system. This way, the information related to the knowledge modelling layer is stored in a database, which students can update using their mobile phones. The left hand side of figure 3 depicts the students' view of the system after logging in. As shown in the picture, the toolbar in the top of the screen allows the student to navigate through the different options of the system which at present are: to view his/her profile, to rate his/her knowledge gained on a concept, and to set his/her general status and his/her status concerning the lecture's activities. Seeking to facilitate the use of the system in different platforms and operative systems, the representation layer of the prototype has been implemented using Java and the NyARToolkit library [21]. On the right in Fig 3 an example of the image that the lecturer would have at a particular moment during a lecture is depicted. Simply by taking a look at the symbols superimposed over the

students, the lecturer would know that two of them are following the explanation correctly while the other one is rating his understanding as poor.

With regards to the AR device to be used by the lecturer we are currently exploring two different solutions. The first one is based on the use of a mobile phone, which will provide both the camera to capture the image of the classroom and the visor to retrieve the augmented version of it. The second possibility is based on the use of a set of cameras which capture different views of the classroom. These views are sent to a PC for processing and adding the corresponding augmented symbols, and then sent to the lecturer via a tablet PC which he or she can carry in his or her hands. The first solution has an advantage over the second in that it does not require any setting up in the lecture room. On the other hand the second solution would be more suitable for large classrooms, in that it would facilitated the recognition of the students positioned further away in the classroom, just by placing additional cameras close to them. The main drawback of both solutions is that they decrease the transparency of the system as they require the lecturer to perform specific gestures, which would give away his or her intention and interests.



Fig. 3. Captures of student and lecture views of the ALF system.

## 4. Discussion

The use of the described system during a face-to-face lecture might report many benefits to both the lecturer and the students. First, from the perspective of the former, it would facilitate the retrieval of feedback from the students. For instance, just by taking a glance at the classroom through the AR device and checking if the majority of the students show a green symbol next to them, the lecturer could know if most of the students have understood his or her last explanation. Although it can be argued that this functionality is already provided by current CRSs implementations, the proposed system allows a smoother integration of this action in the lecture flow as it saves from having to interrupt it to perform it. Furthermore, while the system preserves the anonymity of the students' answers and current status from other students, it allows the lecturer to instantly identify which of the students have raised them. This helps to avoid the miss-use of the system by the students, for whom the total anonymity provided by a standard CRS could constitute a temptation to introduce humoristic answers [10]. Second, from the perspective of the students, the system might help them to feel less reluctant to participate and communicate with the lecturer, as the rest of the classroom cannot witness fellow students giving wrong answers. This way, student embarrassment in question rounds could be avoided if the teacher only addresses those students who exhibit a specific symbol indicating that they know the right answer.

The maintenance of models of the lecture and the students' knowledge can also support the implementation of other interesting functions. For instance, when a student raises a question, the lecturer could immediately retrieve the main information about his or her background, last test results or lecture's attendance rate, for example. Furthermore, when a student shows a symbol which indicates a poor level of comprehension on the subject, the lecturer could make use of a "diagnosis mode," which could automatically retrieve and propose candidate causes for the learner's misunderstanding based on the information about him/her stored in the system. Once the lecture is finished, the system logs offer the lecturer valuable information about students' responses to the proposed activities, which can be used to identify problems or drawbacks and to refine the lecture plan.

In order to enjoy all these benefits, a practical implementation of the system has to take on a variety of technological challenges, two of which can be clearly anticipated. The first is related to the technology used for recognizing the students, which should be accurate enough to allow recognizing students positioned in the back of the classroom, and at the same time provide real-time processing satisfactory results. Instead of using one single camera to identify all the students, a possible solution to the problem would be to use several cameras placed in different positions in the classroom, as explained in the previous section. Another solution could be the use of a classroom positioning system able to recognize a pre-determined set of positions. This will require initializing the system at the beginning of each lecture by indicating which student occupies each position. The second problem lies in providing the lecturer with an adequate device for viewing the augmented representations being transmitted. On the one hand AR glasses are still too unwieldy to be used in a real lecture but, on the other hand, the use of mobile devices, tabletops or laptops would decrease the transparency of the system. However, as in many other cases, it is very likely that as AR technology matures, it will be easier to overcome this problem. Finally, it is also necessary to bear in mind other problems related with the lack of privacy. For instance, some students may feel reluctant to use the system as they may not like the idea of being recorded with a camera during the whole lecture.

### Conclusions

In our opinion, it is very likely that lectures in a near future will combine and integrate different technologies, like videoconferencing, virtual worlds or AR for enriching participant communication and overcome barriers of physical location. Following this idea, in this paper we proposed ALFs, a system which make use of AR techniques to allow an instant and private communication between students and lecturer. With the aim of exploring and evaluating the actual state of the technology and its real possibilities of practical use, authors are currently working on different implementations of the proposed system. These include the adaptation of the representation layer for its use with AR glasses, and a prototype of the system for distance lectures supported by virtual worlds. Different sets of symbols and possible ways for representing the status and the knowledge of the students are also being investigated which will hopefully facilitate their identification by the lecturer.

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