Remote Presence: Technologies for 'Beaming' Teachers Where They Cannot Go

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***Abstract*--There are schools where good teachers do not want to go. The reasons for this are discussed in the context of both developing and developed economies. It is proposed that learning in such areas, particularly for children, needs the support of appropriate technology.**
The concept of "presence" of a mediator is discussed in the context of distance education. Some results from experiences in teaching at a distance over Skype are discussed along with some of the key technology related issues for such remote teaching.
A design is presented for an experimental ROV (remotely operated vehicle) device for distance education and its possible implications discussed.
The term "Instructional Robotics" is suggested.

***Index Terms*--Distance education, ROV, remote presence, remoteness, mediation, children's education**

I. Introduction

There are, and will be in the foreseeable future, places on the planet where, for whatever reason, good schools do not exist and good teachers do not wish to go. In such areas, it is reasonable to expect that educational technology and distance education will have a special role to play. In this sense, educational technology and distance education are meant to "level the playing field" and provide equal opportunity for learners in areas where traditional schooling of adequate quality is not available. In this paper we will examine the effects of "remoteness" on the quality of education, the use of technology for teacher "presence" (the quotation marks will be justified) and finally propose designs for new technology that may provide better opportunity for learners in disadvantaged areas.

II. Learning and "Remoteness"

The quality of traditional schooling reduces when schools are farther away from urban areas. Figure 1 shows the performance of primary school children in tests of English, Mathematics and Science as the schools get more distant into rural India from New Delhi.

As is clear from the figure, there is a decline in performance with geographical remoteness from New Delhi. The reasons for this have been attributed to the lack of and willingness of teachers to work in these areas [1].

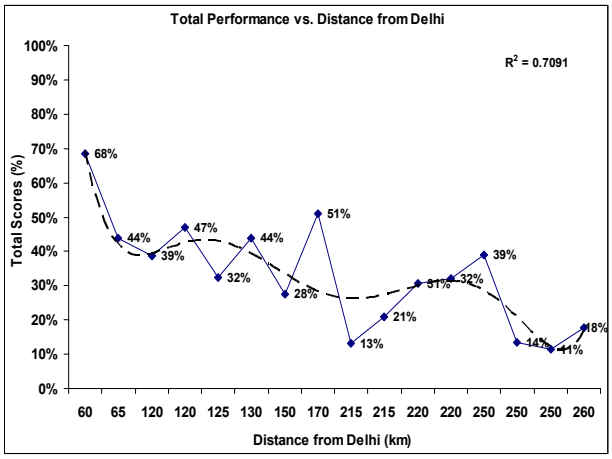

Figure 1. Performance of schools in remote areas in northern India

One might argue that the situation will be different in developed economies. In countries with developed economies the disparity of facilities and living standards between urban and rural areas are significantly lower than in countries with developing economies.

The quality of life in most geographically remote areas of the developed world is sufficiently good to attract and sometimes strongly attract good teachers. However, the performance of schools in such areas is also not uniform. There are schools that perform less well than others. Here too, there are areas where good teachers will not go. Such areas in the developed world are not necessarily remote in a geographic sense. But they are remote in other ways. There are areas in big cities that are socio-economically remote, areas that are religiously remote or ethnically remote. Figure 2 shows GCSE performance of schools in the UK against the density of subsidised council housing in those locations.

There is a clear decrease in performance in the areas with higher subsidized housing. The problem of remoteness is different in developed economies, hence the parentheses used with the term "remoteness" in this paper.

Is it possible for teachers to live in areas that they prefer and still be "present" in schools where they do not, physically, wish to go?

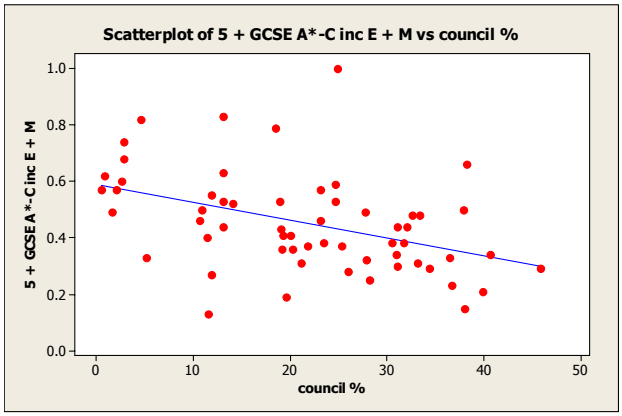

Figure 2: School performance against Council housing in the UK

III. Presence

Distance educators and engineers have attempted to address the issue of remote presence of teachers through several methods. Starting with printed material that brings a teachers influence to remote learners, to synchronous video conferencing, more than a century of development of remote instruction have produced new methods of learning of varying effectiveness. It is beyond the scope of this paper to describe the various successes and failures of these methods. However, in the author's opinion, there is a consensus that, for traditional classroom education, there is no substitute for the "real thing", that is, the presence of an effective teacher in a classroom. If this contention is accepted, one can, nevertheless, construct a thought experiment to test the effectiveness of the technology of remote presence.

A. A thought experiment on remote presence

We can imagine a technology where a teacher is projected into a classroom in the form of a life-sized, three dimensional image that is indistinguishable from a real person. The teacher is physically located in another location where she, in turn, is in front of a life-sized, three dimensional image of her class and learners. Both can hear each other in full spectrum audio, real time.

One can then argue that, since the audio-visual sensations of the teacher and learners are now indistinguishable from real, physical presence, the teaching-learning situations are identical. We will assume that in traditional classroom instruction, tactile and olfactory stimuli are not significant for learning effectiveness (this assumption, may, however, need to be questioned, as follows).

Under the above circumstances, we can conclude that the technology will produce learning outcomes that are identical to live classroom interaction. Indeed, such a setup would, arguably, obliterate any difference between virtual and live education.

In the author's speculative opinion, such technology is twenty or more years in the future from now (2009). In the meanwhile, we can approximate such a situation in various ways as described below.

B. Presence and media

Synchronous or near-synchronous presence of teachers can be achieved through various ways at the present time. These include:

1. Phone, mobile and telecommunication based video conferencing
2. E-Mail
3. On-line chats
4. Virtual environments such as Second Life
5. Audio chats
6. Video chats

The author has conducted over 20 hours of classroom teaching between Newcastle, UK and New Delhi, India using Skype, a popular peer-to-peer (P2P) communication system over the Internet. Six adult learners were addressed in a classroom equipped with a web camera, microphone and a projection screen. The results were found to be satisfactory under the following circumstances:

1. Uninterrupted, reliable and more than 1Mbps bandwidth at both locations
2. A projection system at both ends providing near life size images of the teacher and learners
3. A directional microphone, such as those on most camcorders, that does not pick up the feedback from the speaker at both locations.
4. Adequate lighting for clear video images

C. The future of presence

Based on the above experience, our observations are:

1. The size of the image seems to have a significant effect on the visual experience of both students and teachers. It is suggested that the images should be as close to life-size as possible. The effect of the size of image with learning effectiveness in video conferencing seems to require further investigation.
2. The quality of audio needs to be as close to the real frequency spectrum of the speakers as possible. Telephone quality is barely acceptable. Fortunately, Skype provides excellent voice quality and, with good speakers, the resultant audio is almost indistinguishable from a real voice and people can be easily identified by their voices.
3. It has been assumed above that the tactile and olfactory senses are not likely to be important to traditional classroom instruction. Curiously, in the author's experience, this may not be the case. While conducting the sessions, it was noticed that the different weather and environmental conditions between Newcastle and New Delhi seemed to affect the energy levels and, therefore, the teaching and learning processes of both sides. It is speculated that having a common environment may be important to effective

interaction over distance and this needs further investigation.

Based on the above observations, we propose the following facility for further experiments with teaching-learning over Skype or similar environments:

1. At the classroom end, an appropriate web camera, audio system, PC, broadband connection and a projection system. The PC should also contain an environment sensing system that can measure the temperature, humidity, ambient light and ambient noise levels in the classroom, see for example [2]. Learners can be seated in a classroom arrangement with a projected wall in front instead of the usual blackboard.
2. At the teacher's end, a small room of about 3x3 metres is required. The room should not have windows and should be equipped with a projection system projecting on one wall. The other wall should have a conventional blackboard. A PC with broadband, web camera, microphone and an audio system should also be installed. The room should also be equipped with an air conditioner, a humidifier, a heating system and variable intensity tungsten and fluorescent lighting. The PC should be capable of operating the heating, cooling, humidifying and lighting system. Alternatively, these systems can be operated manually. Environmental data from the remote classroom should be used to create the same ambient light, sound, temperature and humidity for the teacher.

It is expected that such a setup will offer a significantly real experience for both remote learners and teachers towards "remote presence". A teacher equipped with such a facility would be able to address classrooms across continents and time zones.

IV. Self Organised Mediation Environments (SOMEs)

Using the concepts described above, we decided to test the feasibility of such remote presence based interactions.

In response to an article in the Guardian newspaper [3], UK, the author received offers from over 200, mostly retired, teachers who were willing to try this method. To date five teachers have spent over 15 hours with slum children in Hyderabad, India. The teachers interacted from Newcastle, UK over broadband on both sides and with screens projecting the teacher and her class in life size images.

A. Instructional Robotics

One of the things that many teachers do in classrooms is to move about. In the design described above, a teacher can pace in front of the blackboard, however, she cannot actually enter the classroom or go up to a student. In what follows, we will describe an alternative design for a remote presence system that enables a teacher to control a remotely operated robot inside the classroom. This is an area that appears to be mostly unexplored at the moment and should, perhaps, be named "Instructional Robotics".

Photo1. Slum children from Hyderabad, India appear in life size on a Newcastle, UK, wall.

Photo2. A mediator from Newcastle, UK appears life size inside a slum facility in Hyderabad, India.

V. ROVs

Remotely operated vehicles, called ROVs have been in operation for several decades [5]. Perhaps the most famous of these is the Pathfinder ROV, sent by NASA to explore Mars and controlled from the Earth. ROVs are not robots in the true sense since they are not capable of autonomous movement or decision making but are controlled remotely by humans.

ROVs have been used extensively for space research, undersea applications and defense technology. Unfortunately, all such applications have budgets far in excess of any that are imaginable in educational applications. In what follows, we will describe the design of a low cost ROV for use by teachers to interact with learners in remote locations. The ROV will be controlled over the Internet, much as remote web cameras are.

VI. Design of a Teacher's ROV

A ROV for use by teachers should have the following properties:

1. It should be able to move over a level surface, under the control of a teacher from a remote location, using the Internet.
2. It should be able to provide an image of the classroom to the teacher so that she is able to avoid obstacles.
3. It should show the face of the teacher as an image on its "head".
4. The teacher should be able to remotely turn the "head" to look in different directions.
5. It should enable a teacher to zoom in on a feature, such as the notebook of a student.
6. The teacher should be able to speak through the ROV in a natural, real time voice.
7. The teacher should be able to listen through the ROV in real time through stereo microphones so that she can detect the direction a sound is coming from.

In the author's opinion, all the necessary technology for building such an ROV for teachers is currently available.

A. Remote control

Remote controlled vehicles are commonly available as toys. It is a relatively simple task to interface the remote controller of such a toy to a PC such that the vehicle can be controlled with a mouse. Moreover, if this PC is connected to the Internet, the vehicle can be controlled from any computer on the Internet. The author was able to build a prototype vehicle of this kind several years ago.

Photo 3. A remotely operated vehicle with camera in the Author's lab, 2003

B. Computer, connectivity and cameras

The remote controlled vehicle should have an onboard computer. This can be an inexpensive, light and small laptop that are now available for under USD200. These laptops have built in web cameras, and WiFi connectivity. The entire laptop can be mounted on a pan and tilt platform that are readily available. In effect the laptop is then able to drive the vehicle it is on, as well as turn and "look" in any direction as directed by its Internet connection. The display of the laptop would show the face of the remote teacher in real time. A speaker and microphone arrangement on the vehicle will enable the remote teacher to speak and listen in real time.

The ROV would be powered by rechargeable batteries. Indeed, with a little modification, the laptop's own battery should be able to power the whole system.

The connectivity of the ROV will be through wireless from any broadband connection in the school.

It is interesting to note that robots in the context of education are completely restricted to the teaching of robotics itself. There are numerous cases of where students are encouraged to build and operate robots in order to learn how to do so [4].

The author was unable to find any applications of robots for teaching in primary schools. There are occasional proposals on the web [6]. Moreover, most of these proposals and pilots concern the use of autonomous robots to replace teachers [7] rather than ROVs that can be used by teachers to 'go' where they cannot be physically present.

The present suggestion is to use ROVs that can be remotely controlled by teachers to conduct lessons and tutorials in schools. This will enable schools in remote areas to have access to teachers that they would, otherwise, not have had. Unlike the application of Skype, described above, such ROVs operated by teachers would be able to move amongst the children, providing, when necessary, individual attention to a particular child.

Each school would need to own one such ROV and different teachers from remote locations can take control of the ROV at the appropriate time.

Such ROVs can also be used to invigilate examinations at a distance. This has been a long time problem in distance education and certification.

It should also be mentioned that ROVs similar to the one designed above are already beginning to appear in the home entertainment markets (Photo 3).

VII. Conclusion

We conclude that P2P and ROV technology can be used to construct systems for effective remote teaching and learning. The technology for doing so exists already. Instructional Robotics of the kind described in this paper would have the potential to address the problems of education in areas where good teachers will not go.

Photo 4. A web controlled home ROV

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