Effective desktop videoconferencing with minimal network demands.

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Desktop Videoconferening (DVC) has been shown to effectively support remote tutorials, but specific video channel requirements are not known. There is a perception that higher levels of image quality will enhance the effectiveness of the tutorial, and this has implications on scarce network bandwidth. If it can be shown that low levels of image quality are not detrimental to learning opportunities, then the use of DVC will be more attractive to institutions inhibited by fear of high network demands.
Limitations in current methods for assessing video channel quality are discussed, and a new scheme for tutorial content quality analysis is outlined. The scheme has been applied to data gathered from a trial involving 30 students studying for an accredited university module. The results show that increasing the quality of the video channel resulted in no measurable increase in the quality of dialogue within the tutorials. The conclusions are that low quality images are not necessarily detrimental, and therefore DVC could be endorsed more readily where bandwidth is limited.

Desktop videoconferencing (DVC) appears to offer much in its ability to support essential learning dialogue at a distance. Multi-user versions allow participants to sit in front of their computer system, with its screen, microphone and camera, and each participant can be viewed in a separate image as the remote participants speak to one another in a naturalistic way. Affordable DVC has only recently become available in UK higher education institutions (HEIs), as equipment costs have reduced (i.e. processing power, cameras, sound and video capture cards), and low-cost or free non-proprietary DVC software and associated tools are now available. Network infrastructure has also been improved in many institutions which allow a good level of connectivity. In view of the emerging growth and possibilities afforded by DVC, it is important that the merits and limitations of the technology in a scalable educational setting are clearly known. To date, few rigorous studies have been undertaken using DVC in this setting, although there are a few notable exceptions (Buckett *et al.*, 1995; Hughes and Sasse, 1997; McAndrew *et al*.,1996). Most DVC investigations have been conducted in isolated contexts, or in business environments (Whittaker,1995; *and* Tang and Isaacs, 1995), and these cannot necessarily be assumed to inform other contexts. Several issues in the educational arena still remain unclear.

Effective DVC Environment

In an earlier piece of work, this author outlined how DVC could be use to form an effective learning environment, which capitalises on the merits of DVC without being swamped by the limitations of restricted telepresence and audio quality encountered in many room-based videoconferencing trails. It was proposed that DVC should be used for tutorial support to maximize the benefits of small group interaction, and not primarily for content delivery which can often be more effective using books, videos and multimedia CD packages (Hearnshaw, 1998). DVC has shown itself to be a competent tool for supporting remote tutorial dialogue interaction. Such support is vital if students' conceptualisations are to be effectively honed and deepened (Laurillard,1993; and Mayes *et al.* 1994).

Video Channel Requirements

In identifying a valuable tutorial support role for DVC, a major issue emerges in relation to its specification. If high quality video images are to be relayed then the video channel can easily consume large amounts of network bandwidth. These demands far out weigh those of the audio channel, and therefore the costly requirement of providing for the video channel is likely to dissuade many institutions. There is also uncertainty as to the actual benefits and requirements of the video channel. Some feel that the video channel is superfluous, and that it adds nothing to the outcomes of collaborative task performance. Others feel that it does (or must) add an important communicative and social dimension. (See Whittaker, 1995; Anderson *et al.*, 1996; Bruce, 1996; *and* Fowler and Mayes 1997). In partial answer, one would have to assume that in this age of multimedia communications it is unlikely that students will be satisfied by audio-graphics technology - whatever evidence is presented in its favour. The question then arises as to the level of video quality that is necessary. Various trials have been undertaken to assess the purpose of the video channel in isolated and decontextualised environments (references given below), but by their nature, and the limitations of their methods, the investigations have not taken into account the full range of factors which influence outcomes in a typical tutorial environment. With such effects as autocompensation (where students may benefit from difficulties), and the influence of context, perception and personality, it is right that DVC be assessed in an educational context. (See also Draper *et al.*, 1994; Anderson and Garrison, 1995.) An approach is therefore required which can evaluate the effects of different levels of video channel quality within actual tutorials. If the question of appropriate levels of quality can be answered, and the bandwidth requirement for the video channel is modest, then the use of DVC can be endorsed more readily within the limitations of HE resources.

Approaches to Channel Quality Assessment

The ability of a communication channel to convey information is related to the quality of the channel, but assessing channel quality in relation to a human as the end receiver is inherently difficult. Although changes can be made in the technical quality of the channel, these may not relate directly to changes in perceived levels of quality. The rating of

video and audio quality, therefore, has often relied on a subjective approach, where perceptions and outcomes are assessed, as opposed to measuring strict technical channel parameters. However, perceived quality will change between different people and between different task requirements (Watson and Sasse, 1998).

Unconvinced by the reliability of subjective evaluation methods, Reeves and Nass (1996) sought to objectively measure the effects on mental engagement and memory recall for changes in quality and size of video images. Variations in recognition rates were correlated with video image size and quality. Secondary task analysis was also used, which measures the candidates (secondary) reaction time, while the primary task (watching different video images) was undertaken. The methods are objective, because the participants do not require introspection or an awareness of what and how they are being measured, and are therefore less likely to bias results by affective influence. A disadvantage is that the study must be de-contextualised, as it would not be possible to undertake this in a *real* teaching situation. In addition, increased engagement with the image, and improved recall of images, may even be counter-productive, as tutorial students should be applying themselves to the subject content and not the image of the speaker.

An alternative objective method has been to assess changes in participant interactions as a result of changes in the video channel. Remote participants are set a short collaborative task for which they must converse and interact over the communication channels (O'Malley *et al.*, 1996, Anderson *et al.*,1996; *and* Bruce, 1996). The data gathered typically identifies relative levels of task performance, dialogue length, number of interruptions and dialogue structure (e.g. turn-taking). However, such indicators are too crude a measure to assess quality in an educational setting. A solution, therefore, could lie in an assessment of tutorial dialogue quality.

Tutorial Content Quality Analysis

If content quality analysis is to prove useful, then a scheme that can compare the quality of tutorial dialogue is needed, and it must not be subject to the bias of the tutor. Comparisons would be made between the discourse quality before and after quality changes. The quality of dialogue may not need to be assigned an absolute value, as it may be sufficient to recognise relative variations. This will not yield data on non-verbal communication changes, or changes in perceptions, etc., but will be an aggregate measure of learning talk. And as dialogue quality is such a strong and direct pointer to the appropriateness of learning support, it can be a good medium for highlighting the impact of influential change (Laurillard, 1993). The proposed method is to undertake a content discourse analysis on recordings of tutor-less tutorials and then identify resultant changes in the quality of the tutorial content when the quality of the video channel is changed.

Content Analysis Data Gathering

As a suitable content analysis scheme does not exist, several schemes were instrumental in guiding a new scheme. The main contributions came from Ober *et al.* (1971), with their *Reciprocal Category Scheme* and *Equivalent Talk Categories*, and also Powell (1974), who devised a method to analyse the quality of tutors, and Henri (1992), who presents a framework for analysing Computer Mediated Conferencing. The observational scheme required for assessing the quality of tutorial support offered by DVC was not intended to identify processes and strategies of learning, but rather to serve as a benchmark for comparisons between changes in conditions. A scheme was developed which could identify variations in the occurrence of aspects that enable learning to take place, rather than to identify variations in cognitive styles or learning outcomes. Primarily, the scheme is designed to estimate the educational value of the students' discourse, by recording the number of *learning enablers* that occurred. These take into account dialogue that is capable of facilitating learning in others, and not just demonstrating the knowledge of the speaker. For example, some re-iteration may prove little about cognitive ability of the speaker (as it hardly demonstrates the ability to recall), but it may prompt others to learn by highlighting a point which they had missed earlier.

A direct *learning enabler* will be any aspects of tutorial dialogue that:

C presents subject content information,

C requests subject content information,

C interacts with the presentation or request.

A speaker who presents subject content will be articulating and reinforcing their knowledge, and the listener will be given the opportunity to reinforce or challenge their own knowledge. The unit of analysis will be each education point made by a student, and there could be several points in one sentence. The relative merits of different enablers *cannot be classified in an absolute way* irrespective of context (i.e. the aptness of the comment for the audience's needs). The authors of the various taxonomies and categories of learning are also reluctant to place a value judgement on each type of cognitive and affective processes that can be observed. These *learning enablers* are therefore only pointers to what might encourage learning, because their final outcome cannot be identified. For the purposes of this research, the *quality of the tutorial* will be taken as being directly related to the *learning-enabler* value of the tutorial dialogue (in line with Laurillard's, 1993, conversational framework model). An indirect *learning enabler* is an encouragement, or social interaction, or opportunity to participate, etc.

The most relevant direct *learning enabler* tags are as follows:

- **C** **ds**: **dependent** (related) **surface**, (a point or an idea that has been expressed before or is of small importance and requires a small thought above repetition),

- **C** **dd**: **dependent** (related) **deep** point (a useful addition to the discussion selected with some thought),

- **C** **ri**: **repeated item** (surface repetition without requiring thought),

- **C** **ad**: an **agreement direct** (spontaneous or non-spontaneous to a specific explanation or point [asked for or not]),

- **C** **rd**: **request deep** - a request for specific information from others pursuing a specific line of enquiry (e.g. 'but how does it do that?', or 'what does *xxx* mean?'),

- **C** **rg**: **request general** surface - a general request for information (e.g. 'what's the answer to this question'),

- **C** **ra**: a **request** for **affirmation** (e.g. 'is that correct?', or 'do you agree?').

The Environment for Data Gathering

This author had previously conducted DVC trials over the UK JANET MBone (multicast backbone), where students where studying a distance learning course at a variety of remote University sites, and were tutored on a weekly basis using multicast DVC (Hearnshaw, 1998). The DVC tools comprised of Robust Audio Tool (RAT), VIC (video tool) and WB (shared whiteboard). (A full list of software tools with descriptions, references, and down-loadable code is available from *http://www-mice.ucl.ac.uk/multimedia/software*). Course content material was provided on a self-study multimedia CD ROM, and students were sent coursework questions each week in order to dictate the pace of the course and to elicit feedback on academic progress. After receiving in the students' coursework for that week, each DVC group tutorial was used to discuss points arising either because of deficiencies in students' answers or to discuss new points. To realise the benefits of peer tutoring, and reduce the tutors contact time (costly for a small group), the one hour tutorial was divided into two halves, tutor-less and then tutored.

This DVC tutorial environment lends itself to data gathering for the content analysis scheme proposed above for the following reasons:

1. As the first half hour discussion time does not involve the tutor it can form an ideal opportunity for data gathering - which will not be biased by the tutor's direct input.
2. Data gathering can be performed unobtrusively in a real and appropriate learning context, and so any finding are directly appropriate to the specification of the tutorial use of dialogue intensive DVC.

If the quality of the video channel image can be increased half way through the duration of a new trail, then the number of *learning enablers* occurring during each session for the first half of the course can be compared with the number occurring in the second half. Analysis of results should indicate if the number of *learning enablers* had changed in relation to increased video channel quality.

Data Gathering

In order to apply the new content analysis scheme, a trial was initiated involving 30 final year undergraduate students studying an externally validated half-unit module. The students were divided into 6 tutorial groups of 5 students each. Tutorial sessions were provided for 8 weeks. For the first four weeks of the course the VIC video quality setting were held at 2 frames per second (fps) for a QCIF sized image, and then increased to about 6-8 fps with a CIF sized image, for the last 4 weeks. (Very approximately QCIF is $4cm^2$ and CIF $8cm^2$.) During the first half of each tutorial, the students were asked to discuss new questions given for the tutorial, and each student was responsible for noting the group's answer to one of the questions on the shared whiteboard. The dialogue during this tutor-less part of each tutorial was recorded for analysis according to the content analysis scheme.

Findings

The tutorials progressed sufficiently well to record student dialogue and undertake the discourse content analysis on a sufficient sample size, before and after the video channel quality improvements (n=18). It was felt that the coding scheme succeeded in identifying educational quality through indicators of *learning enabler*s, although there were some difficulties which lessened the reliability of the coded data. Care was taken to ensure that conclusions were based on the analysis of aggregated data (over all groups each week), so that the impact of individual group anomalies would be minimised. The most relevant content category types were deemed to be: *agreement direct, dependent deep, dependent surface, request for affirmation, request deep, request general*. These categories were combined (without weighting), to minimise inaccuracies in placing content under the exact category tag.

Figure 1 Average Occurrences of *Learning Enablers*

The aggregate value of these main *learning enablers* is shown in Figure 1. Week 5 and 7 suffered from some external disruption which probably reduced dialogue quality. The quality changes were made after week 4, and the graph does not show a stepped increase which could be associated with an improved learning environment. The analysis of these *learning enabler* occurrences indicates that *the video channel improvements resulted in no measurable change in learning support enablers* over and above a general improvement week by week. This trend was echoed by analysing the two most influential *learning enablers - dependant deep* and *request deep* - and so the fact that the different content types have not been individually weighted did not have an impact. For some students the subjective opinions recorded in the questionnaire were at odds with the findings, so it is speculated that some students are sensitive to issues of improved visual communication even though in reality this may not generally affect objective learning opportunities. It seems reasonable to suggest that they may wish for more social and psychological support than others. It also seems probable, that if the video channel conveys too much information about the other participants, then the students could be less focussed on the subject content. These observations must be qualified by stating that the outcomes may well be different when the video channel is used for more demanding purposes.

Other findings from the content analysis data revealed that the careful selection of group membership could yield far greater improvements in the interaction quality for some individuals than would efforts spent in improving the video channel quality. One student was seen to have contributed almost nothing during the times when another individual was present - an outcome aggravated by tutor-less peer groups. Another observation, that some students participated very infrequently with or without the tutor being present, is well known by most teachers, but it does highlight how little opportunity some students get to articulate their conceptualisations and have them explored and corrected.

On the whole, students commented very favourably on the benefits accrued from the tutorials. The geographic isolation with DVC allows students to focus on the objectives of the tutorial without distraction. The overall conclusions from these findings must be that there is a strong indication that DVC can be used effectively with low video quality levels which only need consume modest amounts of bandwidth. This should encourage an increased rate of take-up for DVC.

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BIOGRAPHICAL NOTES

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