Towards an objective approach to the evaluation of videoconferencing.

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SUMMARY

The evaluation of learning environments incorporating videoconference technology have too often relied exclusively on subjective data gathering methods. The use of these methods can cast doubt on the reliability of findings, and therefore it is important that a more objective approach can be adopted. The development and application of a new content analysis scheme is presented. It draws on the merits of previous schemes but focuses on factors which contribute to the quality of learning support by using category types readily identified within a videoconference tutorial environment. The strength of this objective approach is that data can be collected in a transparent manner within a representative educational environment. Observations arising from applying the scheme are given. Despite an element of subjectivity, the proposed scheme is thought to provide a useful tool capable of identifying the educational impact of variations within a videoconference learning environment.

INTRODUCTION

Reliable data gathering methods are essential in the evaluation of any educational intervention, so that the use and specification of learning support tools is based on sound evidence. Subjective methods have often been used successfully to heighten awareness of important issues, and are often valuable in the preliminary stages of design, but results must be treated with caution as they are open to subjective bias. These methods are common-place despite their downside, as they are fast and easy to apply, and also because few simple alternatives exist (Entwistle and Ramsden, 1983). Objective methods require control of key variables, but educational environments have many interrelated variables, and there is uncertainty that most significant variables can be held steady while the outcomes of variations in test conditions are monitored. These objective methods are often not a realistic alternative for comparing educational environments, as key variables such as prior knowledge, personality, perceptions, motivation and context must be taken into account (Draper *et al*., 1994; Anderson and Garrison, 1995; *and* Biner *et al*.,1995). Some decontextualised experiments have attempted to isolate and control significant influences, but their results are unlikely to transfer reliably to a *real* learning environment when context is a major influence (Laurillard 1993). In fact, some seemingly negative aspects may actually aid learning (Entwistle and Entwistle, 1992). Several authors highlight a whole raft of extraneous issues which must be acknowledged, such as auto compensation, practice at the genre, and task grasp (Draper *et al*., 1994; *and* Anderson and Garrison, 1995)

The evaluation of videoconferencing in an educational environment is one area that has been dominated by subjective methods because of a lack of realistic alternatives. The educational influence of video channel quality factors (e.g. image size, quality of image, lip synchronisation etc.) are not clearly known, although they have important resource implications. (See Whittaker, 1995, for a general list of factors, Watson and Sasse, 1998, on the difficulty in measuring channel quality, and O'Donnell 1997 on psycho-social issues in videoconferencing). Fowler and Mayes (1997) state that the continual push for higher video quality may result in systems that distract rather then benefit the learner. Subjective methods show that students feel they would benefit from increased video channel quality, but objective tests indicate that the video channel does not influence outcomes (Anderson *et al*., 1996, *and* Bauer *et al*.,1992). However, subjective evaluations have been shown to be unreliable, as for example, perceived video channel quality is influenced by audio quality, and the task at hand (Reeves and Nass, 1996, and Watson and Sasse, 1997). Also in doubt, though, are conclusions based on the objective methods, such as secondary task analysis and collaborative problem solving, because data gathering takes place in laboratory style test conditions, and so there is doubt about the reliability of transferring findings to a representative educational context (Laurillard,1993).

DISCOURSE CONTENT ANALYSIS

One method that shows promise is that of discourse content analysis, as this method does not rely on the ability to assess individual components which form the environment. It has been used many times to shed light on traditional teaching and learning, and there exists an interesting scheme by Henri (1992) to investigate computer mediated conferencing (CMC), but an appropriate content analysis scheme is not available for videoconferencing. The scheme outlined below focuses on evaluating videoconferencing to support remote tutoring of small groups, as this is seen as an effective use for videoconferencing (Hearnshaw, 1998). The scheme could also be modified to suit other similar environments.

The proposed method of discourse content analysis involves using subject expertise to compare recordings of students' dialogue before and after changes are made to the learning environment. To a large extent the quality of a tutorial environment is dictated by the opportunities students have to expose and negotiate their conceptualisations (Laurillard, 1993), and therefore, if the quality of dialogue is seen to improve in a marked fashion after changes are made, then the learning environment will have improved. The advantages of this method includes: data can be gathered in a fully representative educational context, data gathering can be transparent to the participants, the method does not rely on subjective introspection by the participants, and there is no requirement to test the students before and after the intervention. Continuous measurement ensures that any gradual longitudinal improvement can be accounted for, as the students will inevitably become accustomed to the environment and subject matter over time. To make the scheme work in practice, it is also important that data is gathered during tutor-less periods within tutorials, as the tutor will invariably bias outcomes. However, the accuracy of the final results will rely on the effectiveness of the content analysis scheme in identifying changes in the educational quality of student dialogue in an objective manner.

There are many content analysis schemes which have been designed over the years specifically for educational evaluation. Some schemes are practical, such as those which guide teachers in their classroom practice, whereas others consider cognitive processing patterns to identify patterns of how students learn. In order to assess the educational quality of a tutorial a mix of approaches may provide the fullest insight. Henri (1992) identified content analysis as a useful means to assess the written dialogue in CMC, and this method appears to draw out many indicators of educational quality. The analysis of CMC messages is said to be'*... proving a gold mine of information concerning the psycho-social dynamics at work among students, the learning strategies adopted, and the acquisition of knowledge and skills*' . It can allow the educator to '*... recognise the strengths and weaknesses of learners, and to offer adequate pedagogical support*' . Henri's content analysis categories comprise of:

C *Participative*. Compilation of the number of messages or statements transmitted by one person or group.

C *Social*. Statement or part statement not related to the formal content of the subject matter.

C *Interactive*. Chain of connected messages(explicit/implicit direct/indirect response/commentary).

C *Cognitive* skills and processing. Statement exhibiting knowledge and skills related to the learning process (elementary clarification / in-depth clarification, inference, judgement, surface processing / in-depth processing).

C *Metacognitive knowledge and skills*. Statement relating to general knowledge and skills and showing awareness, self control, and self regulation of learning.

In principle this scheme is capable of identifying many useful attributes which would constitute quality within a videoconference environment, although it is apparent that several aspects could not be identified outside the wordy, and often explicit nature of CMC. In verbal conversations, utterances are said to '*radically under specify the speakers' beliefs and intentions'* (Whittaker, 1995). With CMC, there is no communication outside text, and the participants use of text often reflects their knowledge, cognitive skills and learning approach. With videoconferencing, the iterations of dialogue are likely to be more brief, they are spontaneous and therefore less considered, and they are often incomplete due to interruptions. Although these may all appear as negative attributes of videoconferencing, the spontaneity allows participants to receive immediate feedback on their contributions. Issues can be resolved immediately and the conversation promptly steered without the asynchronous lag of CMC. The immediacy of videoconferencing enables participants to encourage one another mid-flow, which can spur the speaker on to new depths. For these reasons, Henri's analysis scheme cannot be applied without modification as a measure of quality for a videoconference environment. The ability of the communications media to relay psycho-social support, such as encouragement, must be identified as an attribute of quality (Fowler and Mayes, 1997), and it must be recognised that cognitive processes may not always be identifiable. Ober *et al*. (1971) incorporated an analysis of affective issues in addition to cognitive issues with their 'Reciprocal Category Scheme'. This captures the '*climate factor*' of the learning environment with such categories as 'warms', 'accepts', and 'corrects'.

Due to the difficulty with identifying the cognitive process categories of Henri's scheme within a VC environment, it is worth considering a tutorial dialogue analysis scheme of Powell (1974) and also another scheme of Ober *et al*.(1971) called 'Equivalent Talk Categories'. Both these schemes share similarities with Henri's scheme but the categories are less theoretical and more readily applied in practice. Taking a phenomenographic stance, classroom dialogue is represented in categories related to surface indications, and therefore does not require the content coder to deduce the most appropriate abstract category. Powell's categories are: giving an opinion, giving information, arguing, asking for information, clarifying, formulating problems, and group process. The categories of Ober *et al*. include: presenting information, questioning, responding, reacting and structuring. In a similar manner to Henri, the categories are grouped into restricted or expanded thinking.

The proposed scheme borrows aspects from these other discourse content analysis schemes. Rather than being swamped with theoretical issues of how to measure the learning that takes place , it also takes a phenomenographic stance and seeks to identify aspects which a teacher/subject expert would identify as contributing towards the educational quality of a tutorial. The scheme is not intended to provide an absolute measure of quality, or to identify processes and strategies of learning, but rather to serve as a relative benchmark for identifying changes - if present - in the quality of *learning enabling* opportunities before and after changes in test conditions are made. If it were possible to give an appropriate weight to each category of learning opportunity, and to quantify the size of each content item occurring within each category, then it would be possible to quantify the quality of a tutorial in absolute terms. However, the authors of the various taxonomies and categories of learning are reluctant to place a value on each type of cognitive and affective processes that can be observed. Powell (1974) and Henri (1992) make no explicit definition of quality. Ober *et al.* (1971) loosely attributes quality with a mixture of interaction types. In addition, the relative importance of each component of quality will vary according to circumstance, and therefore at this stage it may have to be sufficient just to identify the occurrence of each learning opportunity and not seek to determine its size or relative importance. There is also an element of subjectivity when assigning content into categories. These are, of course, some of the reasons why content analysis has not become the evaluators' panacea. But despite limitations, the method can, and has, provided useful insights.

The *unit of analysis* in a content analysis scheme determines how the overall content is to be broken down into manageable items for subsequent allocation into relevant categories. This choice affects how accurately the coded data will reflect the true content of the original discourse. Time division sampling has often been applied (Powell and Jackson 1964, Ober *et al*. 1971). Howell-Richardson and Mellar (1996) used what might seem a more appropriate sampling system for analysing CMC, that of the 'speech act' outlined by Searle (1969). This allows the underlying structure and intention of each aspect of discourse to be identified, but is difficult to apply and still relies on the subjective interpretation of experts to identify which elements constitute quality in a learning environment. A pragmatic solution that will be adopted for the unit of analysis is to use a subject content expert to identify surface items which have the capability of *enabling learning* is the speaker or listener. This would appear to be more accurate than choosing an arbitrary time interval and recording the discourse type occurring within each interval, as some students can articulate their ideas faster than others. Although being partly subjective, educationalists have used such informed opinions in marking students' work throughout the years. It is thought that this element of subjectivity within an objective framework is likely to yield results which are more reliable than the subjectivity of student introspection, or the results of objective decontextualised experimentation.

The new scheme, therefore, estimates the quality of the tutorial environment by identifying the number of *learning enablers* that have occur within the students' discourse. Two types are identified:

C direct learning enablers (broadly of a cognitive type)

C indirect learning enablers (broadly of an affective type)

These are similar to traditional learning categories of 'cognitive' and 'affective' highlighted by Bloom (1956), and are very much in line with the categories of Henri (1992) and Ober *et al.* (1971). The *enabler* categories will, however, be slightly broader, to take into account dialogue that is capable of facilitating learning in others, and not just demonstrating the knowledge of the speaker. 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. Framing an appropriate question demonstrates implicit knowledge, and others can benefit from hearing a question articulated that they may have wished to ask. 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 therefore be any aspects of tutorial dialogue that:

C presents subject content information,

C requests subject content information,

C interacts with the presentation or request (e.g. a firm agreement or clarification of content etc.).

These learning enablers are, however, only pointers to what might encourage learning, because their final outcome cannot be identified. An indirect learning enabler will be an encouragement, or social interaction, or opportunity to participate, etc.

As a secondary issue, other useful pointers may emerge on:

C the process of learning in groups (when the group shows this explicitly),

C participation within a tutorial group,

C other factors enabling or discouraging individual learning,

C the ability to refine the content coding scheme.

Specific content categories which constitute direct and indirect learning enablers were based on those of the schemes mentioned earlier, if the category type could be readily identified within videoconferencing tutorial dialogue.

CATEGORIES IN THE PROPOSED CONTENT ANALYSIS SCHEME

The detailed content tag categories are as follows:

Direct Learning Enablers

- **C** **is**: **independent** (spontaneous) **surface** (a new superficial point),
- **C** **ds**: **dependent** (related) **surface**, (a point or an idea that has already been expressed, or is of minor importance, or requires little thought above repetition),
- **C** **id**: **independent** (spontaneous) **deep** point - the start of a whole new aspect, a new useful item or new perceptive academic point ,
- **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?').

Indirect Learning Enablers

- **C** **sc**: one **social comment**,
- **C** **sa: study aspect** - anything to do with studying at large but not related to the question topic (e.g. how to study, what books to look at, an approach to learning, general study advice),

- **C** **ae**: an **acknowledgement for encouragement** of others ideas spontaneous (e.g. 'yeah' but not a positive full agreement of a point given),
- **C** **ij: inference** or **judgement** shown
- **C** **ca**: one **criticism/correction** to **another**'s point,
- **C** **co**: one **criticism/correction** to their **own** point,
- **C** **oc**: **own cognitive** comment (e.g. 'I'm unsure about my approach' , a comment on their understanding or

knowledge.

C **mp**: **metacognitive point** (e.g. in summarising an approach),

C **gc**: one **group control** point (e.g. ‘lets move on to the next question’, or ‘answer please number one’) , anything that steers the activity of the group or other participants (other that a discussion point),

Useful tags unrelated to learning enablers

C **vc**: comment about the **videoconferencing**,

C **dl**: a long **delay** '*um*' (not short) or similar to keep speaker in the frame (e.g.’ I think..’, ‘let me check ..’), or delay sounds when keeping others at bay while writing on whiteboard, or as a prelude to a disagreement,

C **mc**: miscellaneous comment (as a final catch-all) .

is: independent surface	rg: request general	sc: social comment	ca: criticism - correction another
ds: dependent surface	rd: request deep	sa: study aspect	co: criticism - correction - own
id: independent deep	ra: request affirmation	ij: inference or judgement	oc: own cognitive
dd: dependent deep	ad: agreement direct	dl: delay	mp: metacognitive point
ri: repeated item	ae: acknowledgement for encouragement	mc: miscellaneous comment.	vc: videoconferencing
gc: group control			

Table 1 Content Categories

In practice the recorded tutorial dialogue would be transcribed, and each dialogue item would be matched against a list of category types. For each participant, the number of occurrences of each category type in the dialogue item would be indicated by the assignment of one or more tags. 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) but in general the *learning-enabling value of* the *tutorial dialogue,* as recorded in the most significant learning enabler categories, should be taken as being *directly related to* the *quality of the tutorial*.

APPLYING THE CONTENT ANALYSIS SCHEME

The new scheme was applied to recordings of a class of final year undergraduate students as they participated in weekly tutorials for a half-module course unit. The module content presented an introduction to the theory and practice in the use of computer networks and distributed systems. All students had a basic knowledge of computer applications, although their study programme covered mainly business and management topics. A multimedia CD ROM package was used for self-study content delivery, and tutorials were used for discussing the week's content. Each student could see and talk to other participants as they sat at separate multicast desktop videoconferencing workstations within the university. The tutor participated from another university 15 miles away. Each student was compelled to participate during the tutorless half-hour of their tutorial sessions as each was responsible for canvassing the answer to a set question to be relayed to the tutor in the tutored part of the tutorial. 28 students participated in one of 6 tutorials per week over an 8 week period. A representative selection of the recordings were analysed. (Additional details of the trial are given in Hearnshaw, 1999)

RESULTS

A number of issues emerged when the tutorial recordings were coded using the new content analysis scheme. For instance, it was not possible to know the cognitive depth behind some statements or requests, as many were thought to belong to a category mid-way between dependant deep and dependant surface. It was difficult to know if an agreement was a full acknowledgement or an interjection for encouragement. The difference between ‘yes’,‘yeah’, and ‘yeeeaaah’ could be the difference between agreement or an expression of polite doubt. A request for affirmation was sometimes used to invite a response rather than expressing uncertainty (eg. ‘yeah?’). A statement which followed on from another participant’s statement was thought to be an implicit acknowledgement. A follow-on question could also be an implicit acknowledgement of a previous statement, and may itself contain a dependant deep point. Group control tags were difficult to apply as various forms of control occurred, such as making a joke or other comment which changed the tone or discussion depth.

Some tags were not used at all as there was doubt as to whether they could be applied reliably and consistently. For instance, it was not possible readily to identify inference and judgement. The tags *independent surface* and *independent deep* were not used as all relevant contributions were dependant in someway on the tutorial questions. Criticise another, or criticise oneself could not be tagged accurately as some students would do this implicitly while others would be more obvious.

stu	tag	recorded dialogue
1	rd	Why do you have a limited number of channels?
2	rd	Does that depend on the size of the bandwidth?
1	rd,dd	We'll I mean, for the bandwidth, what is the bandwidth, ‘cause the messages are going to be passing one after the other.
2	ra,dd	Doesn't a channel mean links between nodes?
1	dd	Well a channel doesn't mean links between nodes.
2	rd	Well, well, whats the exact definition of channels then?
1	dd,dd, dd	A channel is just a channel ID, one which the message passes, the call establishment is made for that channel which means it travels a predefined route, so anything on 1 will travel exactly the same route for that whole message, and anything on channel 2 will travel the whole the same route for that particular message. Right, its just a route, preestablished.
2	rd	So, So, alright, if theres a route between me and you and I'm using it sending a message to you and M. wants to get to you yes....
1	ae	Yes
1	dd	... then M. will use a different channel number so I'll know the messages are from him, but it may be a different route that he takes to get to me
2	rg	alright, OK. so that’s that, so, so ,what do you see the answer to 3 being?
1	dd	Don’t know. Yeah, its basically using channel numbers right, thats how its routing, right..
2	ad	Right

Table 2 Sample Student Dialogue with Tag Allocation

Despite the difficulties in allocating some items of content, the vast majority of items could be reliably associated with such categories as: dependant deep, dependant surface, request for acknowledgement, request deep, and request general. For each week the average number of content items occurring in each category was calculated. However, to minimise the influence of subjectivity in content coding, and because categories would not be weighted by importance, and also the fact that the educational quality of a tutorial is an amalgam of several categories, it was decided to group key indicators of learning enablers together.

The main and supplementary groupings were:

A: **ad:** a agreement direct, **dd:** dependent deep, **ds:** dependent surface,

ra: a request for affirmation, **rd:** request deep, **rg:** request general.

B: **dd:** dependent deep, **rd:** request deep.

C: **ds:** dependent surface, **rg:** request general.

D: **ae:** an acknowledgement for encouragement, **ad:** a agreement direct.

The first and main grouping (A) includes all *direct learning enabler* tag types to give an overall unweighted aggregate measure. The second and third groupings (B and C) consider only two tag categories each which are deemed the most significant and least significant pointers to enabling learning. If the results from these subsets exhibit the same overall trend as the broader range of indicators (A) then the decision not to weight the more influential indicators in the main grouping can be upheld. The final grouping (D) identifies two categories associated with encouragement, to determine whether they follow the overall trend.

Week	A	B	C	D
2	71	41	13	23
3	75	46	8	21
4	128	76	32	36
5	104	61	17	37
6	155	90	35	42
7	87	55	16	21

Table 3 Learning Enabler Groupings

Groupings A and B, shown in table 3, exhibit a similar week-by-week trend, which indicates that the broader range of *direct learning enabler* categories taken without weighting has yielded a similar result to the narrower grouping of categories most beneficial to learning. A cursory inspection of these two groups shows a general upward trend week-by-week; however, Weeks 5 and 7 buck the trend. The tutor's diary noted that an external event could have caused the disruption in Weeks 5 and 7. A general upward trend would be expected as students become familiar with their surroundings and their ability to articulate their thoughts. What is significant is that the results do not show a step increase when the technical quality of the communications medium was improved half way through the trial.

Other interesting findings arose which would not have been identified by subjective means. The level of participation for some students increased dramatically when certain dominant students were not present. This led to the conclusion that the composition of the tutorial group may have been more significant for some students than the influence of the communications medium. The recorded content also demonstrated how few opportunities were taken by some students to articulate their understanding, despite the fact that most students claimed to have participated well when directly asked about participation in an end of course questionnaire. The items in the *videoconferencing* category had the unexpected benefit of providing a wealth of useful pointers to issues arising in the usability of the videoconference tools. Students often commented on, or requested help, when they were controlling volume settings, or video image windows, or having difficulty with specific aspects of the shared white board. These comments were of particular value because they had been collected in a transparent manner.

CONCLUSIONS

The new scheme appears to be a useful tool which is capable of providing some measure of objectivity in assessing the impact of variations in a videoconference learning environment. Feedback from applying the scheme in practice shows that certain content categories can be readily identified, and these can form the basis for comparing outcomes during changes in test conditions. However, to reduce the element of subjectivity more work could be done on refining the tag category definitions and the demarcation of the unit of analysis. Accuracy would be improved with the use of several content coders for each dialogue item, and coders should build up a repertoire of representative content types to standardise the way less common items are allocated to an appropriate category. The content analysis results have also drawn attention to other issues which may not have surfaced using purely subjective data gathering methods. The analysis of student discourse has been able to draw attention to issues more fundamental in the learning environment than the quality of the video channel. In principle, the new scheme could also be extended to evaluate a wider range of tutorial conditions - traditional or computer mediated.

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BIOGRAPHICAL NOTES

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