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Human Factors and Interactive Communications Technologies

Dr. Roy Lundin

Abstract: Human interaction through electronic communication technologies produces new virtual communication environments in which human behaviours appear to become modified, and which result in changes in the way people perceive each other. These 'human factors' include ways in which individuals invent communication 'shorthand' to convey messages, inhibition and disinhibition, group dynamics, and intercultural dynamics. These phenomena span all the application areas of education, administration, research, services, social communication and commerce. They also have considerable implications for the globalisation of communication networks where very different types of cultures need to interface. This paper will explore and illustrate some of the ways in which these human factors are expressed, draw implications for training programs and pose some research questions that still need to be addressed.

Resume: L'interaction humaine avec les technologies de communication electronique cree de nouveaux environnements dans lesquels les comportements humains semblent se modifier, ils amenent aussi des changements dans la maniere dont les gens se percoivent 1'un 1'autre. *Ces facteurs humains* incluent les facons que les individus ont d'inventer une communication *stenographiee* pour transmettre leurs messages, leurs inhibitions et leurs desinhibitions. la dynamique du groupe ainsi que les dynamiques interculturelles. Ces phenomenes se retrouvent dans les domaines d'application comme 1'education, 1'administration, la recherche, les services, la communication sociale et le commerce. Ils ont egalement des implications considerables dans la globalisation des reseaux de communication, oil des cultures tres differentes ont besoin d'une sorte *A'interface. C*et article explore et illustre quelques unes des facons dont sont exprimees ces *facteurs humains.* en tire les implications pour les programmes d'entramement et enfin indique quelques sujets de recherches qui meriteraient d'etre explores.

Human Factors and Technology

Imagine, if you can, a small room, hexagonal in shape, like the cell of a bee. It is lighted neither by a window nor by lamp, yet it is filled with a soft radiance. There are no apertures for ventilation, yet the air is fresh. There are no musical instruments, and yet, at the moment that my meditation opens, this room is throbbing with melodious sounds. An arm-chair is in the centre, by its side a reading-desk, that is all the furniture. And in the arm-chair there sits a swaddled lump of flesh, a woman, about five feet high, with a face as white as a fungus. It is to her that the little room belongs....

> "The Machine," they exclaimed, "feeds us and clothes us and houses us; through it we speak to one another, through it we see one another, in it we have our being. The Machine is the friend of ideas and the enemy of superstition: the Machine is omnipotent, eternal; blessed is the Machine." (E. M. Forster, The Machine Stops, 1928).

The interface between humans and technology has been the basis of discussion and training probably since the invention of the club and the wheel. As technology became increasingly complex and sophisticated, so too have the concepts and issues. Technology has profound impacts on the way people live, work and play; however, people in turn shape the technologies to do what is required to make them effective. That is, it is not just a matter of technological determinism. Humans bring their values to the technology and accept that which helps them do what they want to do. The notion of the omnipotent Machine becoming our complete way of living is frightening, but it is an unlikely scenario. In any event, Forster ends his story optimistically.

For example, humanising techniques for teleconferencing has been an important consideration in teletraining techniques for many years. Parker (1984) devotes a large section of his book, *Teletraining Means Business,* on the topic. The frequent use of names, tone of voice, expressing your personality, allowing for some informal chatter, using interactive formats, calling in the reticent and so on are all techniques used to make teleconferences successful.

Human interaction with and through newer electronic communication technologies produces new virtual communication environments in which human behaviours appear to become modified and which result in changes in the way people perceive each other. These range from the ways in which people interact with the hardware, the software, other individuals and with groups. Of particular interest is the extent to which human emotions and 'non verbals' are conveyed through the technologies, including email and audioconferencing where vision is not possible. There is no doubt that even audio and electronic text messages can carry moods and other meanings through tone of voice, nature of the words and symbols used. It is as possible to fall in love online as it was in the olden days through handwritten letters.

This paper will discuss some key observations of such behaviours: I say observations because there has been to my knowledge very little research into the implications of these kinds of behaviours and interactions.

The Help Line

The interface between humans and the hardware begins with understanding to some extent how the technology works. Most people can not or do not want to read the manual, and given some of the jargon and the ways in which some manuals are written this can be appreciated. Stories abound about people ringing the computer Help Line with problems relating to various parts of the technology. For example:

> AUSTIN, Texas - The exasperated help-line caller said she couldn't get her new Dell computer to turn on. Jay Ablinger, a Dell Computer Corp. technician, made sure the computer was plugged in and then asked the woman what happened when she pushed the power button. I've pushed and pushed on this foot pedal and nothing happened,' the woman replied. 'Foot pedal?' the technician asked. 'Yes,' the woman said, 'this little white foot pedal with the on switch.' The 'foot pedal," it turned out, was the computer's mouse, a hand-operated device that helps to control the computer's operations.

> Another rang to report that the coffee cup holder was broken, that the dish was not stable enough to hold the cup and that the whole thing was built in the wrong place and in the way. It was the CD player tray.

Another, rather dramatic example of not understanding the hardware was when a university lecturer was taking part in a videoconference trial to determine whether the institution should invest in this technology. At another, single, remote campus there were 13 students while the lecturer was at the main campus. One of the students was sitting off to the side of the group and over half of his body was 'off camera'. The lecturer walked up to the monitor at his site and tried to look around the corner to see the student's face as though he was looking through a window!

Some of the difficulties arise from the terminology being used. For example, it is common for people to use 'teleconference' when they mean 'audioconference'. 'Teleconference' for years has been used as a generic term to cover all forms of audio, audiographic, computer and video conferencing. A person from the US, a specialist in Early Childhood Education, visited Australia a couple of years ago and was invited to make a guest presentation on a national 'teleconference'; what was meant was an audioconference. However, the person showed up dressed in the best attire and asked where the make-up room was, expecting a videoconference or satellite television presentation.

Shorthand and Signals

Shorthand

Email without graphics has given rise to a whole set of shorthand signals and text-based 'graphics', called 'emoticons' or 'smileys', to convey moods and side comments. For example:

- :-) Your basic smiley. This smiley is used to inflect a sarcastic or joking statement since we can't hear; voice inflection over e-mail.
- ;-) Winky smiley. User just made a flirtatious and/or sarcastic remark. More of a "don't hit me for what I just said" smiley.

:-(Frowning smiley. User did not like that last statement or is upset or depressed about something.

:-I Indifferent smiley. Better than a :-(but not quite as good as a :-).

:-> User just made a really biting sarcastic remark. Worse than a ;-).

>:-> User just made a really devilish remark.

>;-> Winky and devil combined. A very lewd remark was just made.

(-: User is left handed.

%-) User has been staring at a green screen for 15 hours straight.

:*) User is drunk.

(Ref:
<http://www.bic.mni.mcgill.ca/system/world/BigDummy/bdg_46.html>
<http://www.netlingo.com/smiley.html>
<http://clinfo.rockefeller.edu/manual/sminet.htm>)

It is through these types of symbols and side comments that human emotions are conveyed.

Signals

Some research has been conducted into the behaviours, particularly non-verbals, displayed in the use of desktop videoconferencing. Bednall (1995) reported that there were significant differences between individual and group use in this respect.

With regard to 'one-on-one' use, individuals cannot look at the desktop videoconference camera and the screen simultaneously because of their positioning. They usually look at the screen and this can interfere with the interpretations of expressions. Technical solutions using half mirrors have been proposed (Muhlbach, L., Bocker, M. & Prussog, A., 1995), but for practical purposes this doesn't seem necessary. What was also found, however, is that individuals wish to see themselves on the screen to monitor their own image in terms of lighting, hair, focus and so on (Bednall, 1995).

Bednall also reports that when one or more groups are involved in videoconferencing, the nature of the communication changes significantly, and usually becomes more formal with the imposition of procedures and protocols. When voice switching is used a whole new set of social rules on turn-taking is required. He states:

> For example, one study (of student use) revealed the development of a system of visual signals to indicate to other participants about when they want to speak and when they wanted other speakers to stop (Dykstra-Erikson, E. and others, 1995). The following table is adapted from this research. It shows a few of the spontaneous gestures which users developed.

Signing for the deaf is another example of the use of 'signals'. At a trial of the use of videoconferencing for an interpreting service for the deaf it was also found that the technology had specific limitations when it came to signing. The data rate was the first significant factor in that anything under 256 kbps was found to be unacceptable for the reading of signing. The location of the camera for the deaf person and the interpreter was another element of concern because the signing needed to be done directly in front of the camera without too much arm movement or the hands went off camera. The most appropriate location for the camera seemed to be directly in the centre and below the monitor. When the hearing person, the relay interpreter and the deaf person were in different locations, the relay was more difficult than when the deaf person and hearing person were together and both on camera for the interpreter to see. However, this presented a different problem in configuration in that the placement of the monitor for the deaf person needed then to be behind/over the shoulder of the hearing person. This could sure be helped with graphic images allowing the reader to visualize the sceneries!

Gesture	Meaning
Cup hands around mouth, mouth words (no sound)	I want to be heard
Glare at camera	Pay attention to me/I'm paying attention to you
Cover camera lens	Not interested, stop, too much information
Earthquake (shake camera)	Disrupt group
Show watch to camera	Time!
Show inside of mouth or teeth to camera	Disrupt group

(Bednall, 1995, p 7)

Inhibition and Disinhibition

Inhibition and technophobia

Inhibition and technophobia (if such a thing exists) are usually the result of not knowing how the technology works; and these examples might, therefore, have been included in section 2 above. However, there are different elements that contribute to inhibition. For example, people experiencing audioconferencing and videoconferencing for the first time may not know that it is really a limited, 'closed circuit' technical configuration. They think that these forms of communication are like broadcast radio and television and that the whole world can hear and see them. However, when they find out that the sites involved are limited and that the people at those sites, who are probably very well known to them, are the only ones online they become quite relaxed. Indeed they soon seem to lose their inhibitions, as will be explained below.

With regard to email discussion groups or lists there are at least two reasons why people are inhibited in terms of asking questions or making comments. The first is that they may be seen as stupid by others in the group. The second is that individuals feel that they are intruding on an existing 'in group', and this compounds the first feeling. The following quotes from the journal of a fourth year Bachelor of Education student illustrates this.

> An interesting barrier to my own participation that 1 observed was a desire to know who was on the end of the line when I was 'speaking'. It is possible that an inability to participate in the early weeks of the program has limited my knowledge and not that of other participants. The lack of any knowledge about the other participants was disturbing and I found myself not wanting to contribute as 1 was not sure what reception I would receive. In face to face communication, this has rarely been an issue, so it was interesting that it should be an issue for electronic communication.
>
> Upon reflection the absence of any verbal or non verbal feedback as to how your comments are being received was a large barrier for me. Also the contribution is in writing for all to refer to, and or print, and whereas a foolish comment or naive opinion when spoken, is soon forgotten, when it is sent on electronic mail, it is in writing and seemingly more permanent.
>
> One last reason for the lack of interaction with this community, on my part, was due to one or two of the early comments by other participants in which they seemingly criticised another student's behaviour during an ordinary lecture or tutorial. This did not entice me to contribute lest I was treated to the same comments. While it is beneficial that the other students did try to get interaction moving, these comments did interfere with my desire to participate, (unpublished QUT BEd student journal, 1997)

This same 'in-group out-group' phenomenon was observed in two other discussion lists of rural women, Wechat (a closed list) and Welink (an open list).

Disinhibition

Over ten years ago in the USA, a rather large company noticed a significant drop in business - large customers were not renewing purchasing contracts. An investigation was carried out to determine the cause of this slump. It was discovered that the receptionists were sending anonymous, rude email messages to key people in the client organisations as revenge for the rude way in which they had been treated on the telephone by these people. This was out of character for the receptionists, and the phenomenon was dubbed 'disinhibition'.

Since hearing that story, I have observed this phenomenon in all forms of teleconferencing and email. For example:

> During a training program on audioconferencing for telephone operators, a simulation game involving a low level of competition was set up across four groups. The task was to negotiate a satisfactory outcome via audioconference. However, one of the operators decided to filibuster the game and spoke in a loud and aggressive tone of voice from one of the sites for 20 minutes without drawing a breath. The comment at the end was: 'I don't know what came over me! I'm not usually like that!'

> A videoconference trial was being held over a period of a week for government public servants between Brisbane and Townsville, a provincial city in north Queensland. During that week several examples of disinhibition were observed. One in particular involved the State Police. The purpose was for senior officers in Brisbane to meet via videoconference with some relatively new recruits and their mentors in Townsville to determine the effectiveness of the new training program. The four officers entered in full uniform and when this was spotted by the new recruits, they became rather terrified, and one young female, in particular, whispered: 'Look at all that brass!' The facilitator at the Townsville site hit the mute button, and attempted to calm them down and explain their fears away. The videoconference session subsequently went for approximately 30 minutes and during that time the female recruit became increasingly assertive in her conversation with the senior officers to the point where, when one of the officers said he would be visiting them in Townsville next week, she cheekily responded: 'Don't hurry!'

> Flaming on email is probably another example of this phenomenon. At QUT an acting head of the business studies department put an email message out to students along the lines that due to the increased demand on the computing labs there would have to be introduced a set of guidelines regarding access, the length of stay, booking procedures and so on. The message was rather matter of fact, but it drew some of the most vitriolic, racist and foul responses from dozens of students that anyone could imagine. It seemed to trigger some latent issues within the students and, because of the disinhibition phenomenon, they did not hesitate to respond in this way.

Face-to-face, the people in these examples would be far more polite. It is not known exactly why behaviours change in this way, but perhaps it is because they realise that the person at the other end cannot reach across and punch them in the nose. This could prove to be a fruitful area of research.

Individual Interactions and Group Dynamics

Individual perceptions

People conjure up images or fill in 'gaps' in their perceptions when there is no vision or when that vision is distorted as a result of the electronic communications technology. The following two examples illustrate this.

> An online email list has been created in Queensland called Wechat, 'Women's' Electronic Chat', as part of a research project to look at the impact of the use of communication and information technologies by rural women. Many of the people on this list, including two of us men who are part of the Research Team, have not met each other face-to-face. However, recently there was an opportunity for two women, 'SL' and 'CC', who had become very friendly online to meet. SL sent the following message to Wechat after the meeting:
>
> I'm going to tell a little joke about 'CC' and hope she'll forgive me. The first thing CC said to me was, "I didn't think you were so tall!" Well, CC, I know why that is. When I am using the computer I am always sitting down!!!

To which CC replied:

> My ingenuous comment to SL re her height has got me thinking about why we picture people a certain way from their emails. I had this discussion las year with KC (on email)who flippantly said something like she really was blonde (she has dark coloured hair) when we first met after email contact. I have now had the experience of meeting several people I have had email contact with and for some reason SL wasn't quite what I pictured.

And so continued a rather lengthy discussion over a few days about how we picture people before we meet them face-to-face.

Another report came from Mount Isa Mines in northern Queensland. The Human Relations section conducted over 100 interviews during 1995 for staff recruits using videoconferencing. The person in charge said that it was consistently their experience that people look older on videoconferencing than they do face-to-face. Like some of the other human factors reported here, this may well be the result of technical aspects such as camera quality and lighting.

Group dynamics

Group dynamics in face-to-face situations have been a topic for study for many years. However, the dynamics become somewhat different when mediated through electronic communications.

A major technical innovation using videoconferencing for vocational training was introduced in Queensland, Australia, in 1995 and was called 'Videolinq'.

Several Technical and Further Education (TAFE) institutes were supplied with room systems and encouraged to trial teaching and administration applications. One institute had recently established a second campus 100 kilometres away and courses were being taught on both campuses by teachers travelling from the main campus about once a week to the second site. This seemed like a natural setting for the use of videoconferencing so that the classes at both sites could be taught simultaneously.

One such class involved 'personal development' and the teacher volunteered to use videoconferencing. The student responses, however, were something other than what was expected. Because each of the two groups had already developed a strong rapport with the teacher, when both groups became involved in a synchronous session each saw the other as an intrusion on that relationship. The intensity of the animosity was not allayed when the lecturer travelled to the second site to be there personally on alternate weeks. When the Research Assistant visited the groups they almost physically attacked him, blaming the videoconferencing technology and asking him to take it away. The situation continued to deteriorate until the students boycotted the videoconferencing sessions and the teacher had to resume travelling. (Lundin and others, 1995)

A similar situation occurred when videoconferencing was used with a Master of Education group. During 1994, two Queensland University of Technology lecturers trialed and evaluated the effectiveness of videoconferencing to deliver a specific subject from the Brisbane campus to a group of eight mature-age students located in a provincial centre three hours drive from Brisbane. This was a well-established group in that they had studied the same subjects together for the previous three semesters. While there were only the two lecturers in Brisbane, the interactions were relaxed, spontaneous and lively. However, attempts to bring other students enrolled in the same subject on-campus (evening, part-time) into the Brisbane site, with the expectation that this would add to the richness of the discussion, it was seen by the remote site students as an intrusion.

In 1995, another group in the same subject comprised three students from Hong Kong, one from Papua New Guinea and one European-Australian. There was a period of bonding of this culturally diverse group during six weeks on-campus after which two of the Hong Kong students returned home. Videoconferencing was then used to continue this group's activity for the rest of the semester, and they all still felt part of the group. The interactions became quite interesting, particularly in terms of the disinhibition discussed above:

> However, the Hong Kong students also found that they had to make a fundamental change to the way in which they interacted with their lecturers and fellow students. It is not usually within their culture to question lecturers and/or debate issues presented. Although they encounter this shift in operation in a face-to-face situation, they can often 'disappear' in the class group and not enter into discussions. The approach taken by the lecturers coupled with videoconferencing with such a small group of students acted

as a catalyst, enabling them to spontaneously and voluntarily participate in the discussion mode. They adapted to this well and enjoyed the chance for interaction that videoconferencing offered.

This change to basic interactive patterns was the only cultural issue which was evident during the videoconferences. Concerns about English as a second language and any effect on this by the technology proved to be unfounded, with all students communicating freely and easily with each other. The students in Hong Kong became proactive in discussions and exhibited a lack of inhibition often referred to as 'disinhibition'.

A feeling of 'oneness' was observed within the group, overcoming the great geographical distance between them. Of particular interest was the comment by one of the students in Hong Kong. When asked during the debriefing session whether they had felt left out when the Brisbane group was discussing an issue among themselves, the reply was that they did not, they felt very much a part of the group because the Brisbane site had a blue wall as did they in Hong Kong.

This comment was given in earnest, and provides an interesting insight into the psychology surrounding videoconferencing and the importance of room design in promoting interaction. Although not the focus of this study, room design clearly has an impact and is a topic for further study. (Burke, Daunt & Lundin, 1996)

This leads rather neatly into the issues of intercultural communications.

Intercultural Dynamics

The rapid globalisation of education, particularly through the use of communications technology, leads to at least two major cultural/ethnic concerns: first, the dominance of the 'have' countries over the 'have nots (educational invasion), and, secondly, the need for sensitivity in intercultural communications, especially in the design and delivery of distance learning programs.

With regard to the first of these, to quote Rossman (in Murphy, 1994), the countries of the developing world need special attention to ensure true partnerships are realised and educational invasion in the negative sense is avoided:

> My own distance education priority is the developing world. As we try to assist Third World people in developing their own distance education, I'd like to see us have some international partnerships. These partnerships should result from trying to solve basic world needs: adequate food and health care, adequate education, and jobs for everybody in the world. Distance educators should find a way to focus on such crucial needs. Research on solutions to such problems will require international partnerships or teams across all kinds of national and cultural boundaries

> to define a problem, discover alternatives, and explore the consequences of various actions. In other words, international distance education should empower 'collective intelligence', the bringing together of many minds to work on specific global-scale issues. This strategy is possible with the new communications technologies. (Rossman, in Murphy, 1994, 72)

With regard to the second intercultural issue — communication, it would seem critical that the production and delivery of distance learning courses need toi be culturally sensitive - and congruent with the culture of the clients. For example, for most subject areas, simply sending western culture type materials to students in Asia does not seem to be appropriate without some translation.

Intercultural or cross-cultural use of various forms of media have been the subject of research reported by people as Korzenny and Ting-Toomey (1992) and Lester (1996). These and many other research findings are summarised and reviewed by Biernatzki (1995) in an issue of *Communication Research Trends* devoted to "Intercultural Communication'. For example, with regard to ethics, Cooper (in Korzenny and Ting-Toomey, 1992) found that there is a fairly substantial common ground for the establishment of an ethics of mass media applicable to many or most cultures. Lester, however, found that in much of the media there was considerable ethnic stereotyping based on limited knowledge of the producers of the programs about various ethnic groups.

Casmir (in Korzenny and Ting-Toomey, 1992) provided some of the most interesting insights with regard to this issue in terms of a 'Third Culture' which is developed through cross-cultural communications:

> Despite some cross-cultural commonalities, cultural differences not only remain, but remain extremely important as barriers to easy understanding among people of different ethnic backgrounds. Fred Casmir, in his epilogue (Korzenny and Ting-Toomey, 1992, 247 - 262), felt it necessary to stress this point, lest the ideal of a 'global village' be too easily accepted by readers impressed by the cultural similarities highlighted by some of the book's other contributors.
>
> Casmir emphasises that 'in many instances specific types of media consumption or use result, regardless of the intentions of those who present material to their viewers, readers or listeners' (p 250). He feels that the focus of intercultural media use studies should be on the interaction between viewers and the media. In this process, 'third cultures' are constructed which use materials from both the interacting cultures to fill locally and temporally defined functions outside both cultures but are intelligible to the participants from both who are involved in that particular interaction. (Biernatzki, 1995,7)

This notion has considerable implications for global educators and third 'third culture" would seem to be a far more palatable outcome than educational invasion or the melting pot of a 'supra culture".

Being Unreal and the Future

What the future holds for education in terms of the use of the various technologies is, of course, the subject of a great deal of conjecture. There are issues relating to validity of information, the nature of reality, the potential for sabotage, being anonymous, 'genderless', 'ageless' and even 'non-human" through the use of avatars, bots and other forms of Internet software.

Carol Parker (1997) articulates the unreality of the online experience as follows:

> I felt my on-line identity was quite separate from my day-to-day existence. I treated Worlds Chat as a game, and enjoyed the theatrics of donning my avatar. On-line, 1 could be who I wanted to be: young, beautiful, tough, witty, the all-round party girl, almost like stepping back in time to my single days.
>
> I believed I was having fun, and that was all; the actions and words that happened in cyberspace were separate from my real life.

Computers - we will probably be wearing them and this will provide a whole new set of interface implications not yet realised. Given the convergence of technologies and the development of universal communications and data bases, it is becoming possible for learners of all ages to initiate their own educational pathways and learn what they want, when they want, where they want; the ideal of open learning.

> A university lecturer, when marking her students' papers, found references to writings by key people in the field, but she had not yet read these articles. When she asked the students where they came from, they replied: 'The Internet!' She dubbed this 'feral learning'.

As Parker Rossman indicates, there are more questions than answers at this stage with regard to 'free trade' of higher education:

> The agenda for global higher education begins with questions about who is to coordinate and regulate electronic courses offered on network or satellite; who is to set standards, especially when nations and universities disagree; what technology is to be used and how can it be shared; and who is to arbitrate and decide on such matters as degrees and exchange of course credits. Also, what kind of administration and funding can a worldwide electronic university have if it involves many governments, private colleges, and the teaching programs of business corporations (Rossman, 1993, 13)?

There is increasing interest in the notion of megauniversities (e.g. Daniel, 1996) coming into existence with staff and students drawn from the global network. This represents the shift from the university (or school) being a bricks and mortar place to the learner being able to say: 'I am my school' or 'I am my university'. This indicates empowerment of the learners to control their own destiny and provides Rossman with most of the answers relating to the problems of control. The implications of the learner now being able to draw on multiple sources for their coursework, to request recognition for prior learning and to demonstrate competencies through private agencies means that the whole notion of what constitutes an educational institution, versus a community of scholars, needs to be addressed.

The idea of wearing our computer may seem one more step towards our living totally within the machine. In which case let us hope the final scenario is not like this:

> Vashti was lecturing at the time and her earlier remarks had been punctuated with applause. As she proceeded the audience became silent, and at the conclusion there was no sound. Somewhat displeased, she called to a friend who was a specialist in sympathy. No sound: doubtless the friend was sleeping. And so with the next friend whom she tried to summon, and so with the next, until she remembered Kuno's cryptic remark, "The Machine stops."
>
> (E. M. Forster, The Machine Stops, 1928)

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Interactivity in Multimedia: Reconsidering Our Perspective

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Abstract: Touted more often than any other advantage of multimedia is the interactivity that it can provide. Proponents claim that interactive multimedia requires learners to "engage" in the instruction and, thereby, learn more effectively than through passive instructional methods such as text, video, or classroom lectures. The problem with this claim is that interactivity is seldom, if ever qualified. Focusing on closed (non-networked) multimedia systems, the author will review some of the perspectives on interactivity in multimedia, identify the salient characteristics of meaningful interactions, and outline some basic considerations for designers of interactive multimedia instruction.

Resume: Vente plus souvent que tout autre avantage du multimedia est 1'interactivite qu'il permet. Les partisans pretendent que le multimedia interactif requiert que les apprenants s'impliquent davantage dans leur demarche educative, et ils affirment que ces derniers apprennent d'une maniere plus efficace qu'avec les methodes d'enseignement plus passives ayant recours au manuel. au video ou au cours magistral. Le probleme avec cette pretention est que cette interactivite est rarement sinon jamais evaluee ou nuancee. Portant notre attention sur des systemes multimedias autonomes, c'est-a-dire non-interconnectes. I'auteur reexaminera certaines perspectives actuelles sur 1'interactivite du multimedia, identifiera les caracteristiques remarquables d'une interaction significative, et decrira brievement certaines considerations de base pour les concepteurs d'un enseignement utilisant le multimedia interactif.

The Latest Educational Buzzword

In the same way that "user-friendly" once pervaded the computer marketplace and "low-fat" has become a standard in our grocery list vocabulary, the term "interactive" seems to have become the norm for describing educational events and instructional materials. Educational course guides, workshops, discussion groups, and television are commonly billed as interactive, in an attempt to "cash-in" on the prevailing assumption that interactivity translates directly into effectiveness. Nowhere is this better illustrated than in the use of the word "interactive" to promote instructional multimedia programs. A recent memo at the University of Saskatchewan highlighted three proposals that were successful in winning grants for course development; ranging in subject matter from clinical gross anatomy and physical therapy to political science; the one thread common between them was their interactivity billing.

As is the case with any word that is overused by the general public, the word "interactive" has arguably begun to lose some of its impact in recent years. There are so many interpretations of what constitutes interactivity, and so few methods for determining its effectiveness, that lately programs touted as interactive are more likely to raise skepticism than enthusiasm. This is further complicated by the fact that interactivity varies greatly within educational contexts; the type of interactivity that is possible in a human-to-human experience is qualitatively different than that which is possible between a human and a computer program. Even within the same human-to-computer environment, what's perceived as interactivity may vary greatly between an instructional chemistry course and instruction in political science. While striving to design meaningful interactive experiences in instructional materials remains a worthy goal, unless one has a clear idea of what interactivity is, it can be an elusive target. Does interactivity refer to the concept of learner control and the ability of the learner to determine their own pace and direction through the program? Does it simply mean that multiple media are employed, making the learning experience more of a complete sensory experience? It could be the requirement of clicking the mouse or typing one's response. It could be the ability of the system to recognize and adapt to the performance and learning style of the individual. Perhaps, meaningful interactivity is all of these things combined. Perhaps, it is none of them. Could it be that meaningful interactivity really only exists between two or more people and all of our efforts toward interactive multimedia are merely our best attempts to simulate the real thing?

The goal of this paper is to review some of the various perspectives on interactivity in multimedia that exist in the literature and to identify the salient characteristics of meaningful interactivity in instructional multimedia. The focus will be on closed multimedia systems that are self-contained, stand-alone applications (i.e. programs distributed on either diskette or CD-ROM) as opposed to open or networked systems such as the World Wide Web. A summary of considerations for designers of interactive multimedia will also be presented.

First, There Was Multimedia

Before interactivity in multimedia can be explored, one must first settle on a definition for multimedia. At its simplest, multimedia refers to any program comprised of two or more media, hence the name, multimedia. Schwier and Misanchuk (1993) update this definition by suggesting that today's multimedia productions have their heart, a computer responsible for controlling the actions of the program and interpreting learner responses. For the purposes of this paper, Rada (1995) completes the definition by suggesting that the media involved in a multimedia system must include at least one form of time-based media such as audio, video or animation. By contrast, a product combining only non-time-based media (i.e. text, graphics or photographs) would not be considered multimedia by today's standards.

It is important to further differentiate between the types of multimedia programs that exist. Schwier and Misanchuk (1993) suggest four categories, based on the nature of the content and the intentions of the designer: entertainment, informational, educational, and instructional. Of these, this paper will concern itself with only the final category.

Instructional multimedia refers to those programs that have been designed, intentionally, with the goal of having the user learn the material presented in the program. The focus tends to be quite narrow, with both content and activities carefully designed to optimize the potential for learning. Often, instructional multimedia programs will also make an effort to evaluate the degree of learning that takes place.

The Main Ingredients of Interactive Multimedia

From a review of the literature on designing interactive multimedia, one finds five common ingredients prevails among recipes. The exact measurement and importance of each ingredient toward the development of meaningful interactivity seems up for debate. Forget to include even one of these items, however, and the odds of creating an interactive program are significantly reduced.

Active learning environment

The idea that active learning is a valuable instructional strategy is well accepted in education. Just ask yourself how many times you have seen or suggested a hands-on approach to learning in order for students to better understand a problem or task. It is this ability to activate the learner that stands out as one of the key advantages of interactive multimedia programs. Through question and feedback routines, interactive programs require learners to actively process the information being presented. This mental activity has been shown to help learners better comprehend and remember the information being presented (Jonassen, 1985).

One may argue, however, that active learning environments are not synonymous with interactive ones. While it is relatively easy to program a computer to ask a question, analyze the response (according to its programmed code), and present appropriate feedback, the experience for the learner is finite. Though the learner may still be active in the process, the limitations of computer programming and learner response options often dissolve the illusion of real interactivity.

Learner control

The concept of providing learner control is highly important to the development of interactive programs. Allowing learners to determine the sequence that they will follow, and the time that they will devote to a particular area of the program, has been shown to motivate learners by decreasing their anxiety and improving their attitude toward the program (Steinberg, 1984).

The question of 'how much control is appropriate' is less understood. Some research shows that too much control can result in the learner feeling increased levels of doubt and insecurity (Bartolome, 1994). The optimal degree of learner control should be determined by learner characteristics, the nature of the content, and the complexity of the learning task (Hazen, 1985). In cases where the learner is less able or less experienced, the degree of control assumed by the program might be increased.

Feedback

A critical component to any multimedia interaction is the feedback provided following the learner's response: The more individualized the feedback, the more meaningful the interaction (Bork, 1982). While experienced tutors are capable of considering a learner's response and providing timely, appropriate feedback in order for the learner to better understand or proceed with a problem, a closed multimedia system has limitations. Designers of closed systems must anticipate both correct and incorrect responses to a question and then determine whether confirmational, motivational or instructional feedback is most appropriate (Hazen, 1985). They must also try to plan for the unanticipated responses that will inevitably occur, dealing with them in a constructive, helpful manner. The degree to which these challenges are met largely determine how successful the interactions are for the learner.

Multiple media

According to our earlier definition of multimedia, the presence of multiple, time-based media is integral to an interactive multimedia program. Reality may be represented through digitized photographs and video, detail may be shown by computer graphics, and descriptions may be provided by text, audio, or animated sequences (Haugen, 1992). As with active learning environments, however, the mere presence of multiple media does not translate directly into interactivity. Even when combined with elements of learner control, the use of multiple media guarantees no more than a computerized image finder.

As a designer, one must guard against the temptations that media have to offer. The desire to employ the latest popular technology in an interactive multimedia program is a trap that designers fall into all too often. At one time, it was the overuse of clever audio clips to provide feedback to the learner. While initially amusing, the persistent chime, whistle or trumpet blast quickly became an annoyance to the learner and ultimately, a distraction in the learning process. More recently, the "technology trap" can be seen in the misuse of Quicktime VR™ sequences and Java script animations. This tendency to allow the technology to drive the design can have negative implications for learner control and, subsequently, the degree of the program's interactivity.

> The user will often judge the material as 'good' or 'interesting' just because of the new, technical gimmicks... Being afraid that the user will skip some of the gimmicks in order to reach the learning objectives in a more straight forward way, [the designer] tends to lay very rigid tracks through a complex collection of material. Thus, no real choices may be left for the user. (Haugen, 1992).

To overcome this problem, Jonassen (1985) suggests that rather than start with an analysis of the capabilities of the technology, one must remember to begin with an analysis of the problem and then design an effective instructional approach to solving it. By following this method, the odds are improved that the learner activities and interactions developed are those that are most appropriate to the learning task, rather than those that are simply dictated by the chosen technology.

Learner response options

For the most part, today's interactive systems provide users with two reliable methods for entering information: typing and direct manipulation (e.g. mouse, joystick, touchscreen). According to Jonassen (1988), one might consider clicking on a mouse to represent one of the lowest forms of interactivity, given that only a shallow level of cognitive processing is necessary. By the same principle, a slightly higher level of processing and interactivity occurs when the learner is asked to type in their response or to manipulate screen items into their correct position. In some language learning programs, voice capture is used, offering potential for deeper processing and a higher level of interactivity once again. With the ability to recognize only about 1000 spoken phrases, however, today's interactive systems are still inadequate in this regard (Rada, 1995).

Adaptability

According to a number of researchers, one of the most valuable, yet elusive, attributes of effective interactive multimedia is the ability of the program to adapt to the individual needs and style of the learner (Ross & Morrison, 1988; Tennyson & Christensen, 1988; Jonassen, 1988). In many cases, this adaptability is simply a variation of learner control described earlier in this paper-basic decisions involving the pace and sequencing of content are afforded to the learner in an effort to simulate adaptation in an otherwise rigid environment.

The logical alternative to internal (learner) control is to design for adaptability that is controlled by the program (Ross & Morrison, 1988). In this orientation, the learner's movement through the program is predetermined by the program designer and based on the learner's responses during the instruction. The primary criticism of this approach is the often arbitrary process applied in determining what type and quantity of instruction should follow the learner's responses and what performance criteria must be met by the learner.

At their highest level, adaptive systems are referred to as "intelligent learning systems" and are characterized by elaborate programming that employs multiple variables (Tennyson & Christensen, 1988). These systems not only attempt to diagnose the learner's response and provide him or her with individualized feedback, but they are designed to revise and refine their own databases based on their interactions with the learner.

Not All Interactions Are Created Equal

Interactivity or reactivity?

"No one has yet to program a computer to be of two minds about a hard problem or to burst out laughing" - Lewis Thomas

It's been suggested that to understand the essence of interactivity, one might look back in history to a time before computers and technology confounded the issue, to a time when interactive learning was exemplified by the Socratic dialogue between tutor and student (Bork, 1982; Bork, 1992; Jonassen, 1985). These interactions were dynamic, reciprocal and infinite in nature as the communication between tutor and pupil was unrestricted and each party could adapt to the input of the other. Contrast this with the instructional multimedia programs of today. Highly prescriptive, limited in their ability to accept various learner responses, and subsequently, inadequate in their assessment of a learner's true understanding, these programs attempt interactivity in a variety of ways, but only rarely are they successful.

To accept that designing meaningful multimedia interactions is much more difficult than often suggested, one need only consider the basic premise by which computers operate. Programmed to accept user input via some form of electronic device (e.g. keyboard, mouse, joystick, microphone), the computer can only interpret that response to the extent that its programmed code allows. This results in a maze where accesses are created and clues are provided, but progress through the maze is highly restricted. The spontaneity of exchanges between learner and program in this type of environment can be likened to speaking to an answering machine as opposed to speaking directly with someone over the telephone (Vidal, 1992, p. 205). These inherent limitations of the computer can occasionally be disguised by a clever design. However, they can never be overcome completely as some response or desired path is inevitably overlooked by the programmer. When this occurs, the illusion of interactivity disappears and the learning process is interrupted.

If multimedia programs can only simulate true interaction with the learner, how should they be described? Barker (1992) is one of the few that refers to the reactivity of hypermedia electronic book systems, rather than their interactivity. Jonassen (1985) describes interactive programs as those that provide at least the appearance of two-way communication. This suggests that perhaps quasi-interactive would be a more appropriate term for many programs. Again, I believe the key is not so much in forging another label for interactivity as it is to recognize that different levels of interactivity exist and to strive for designing the highest, most appropriate level possible for the task at hand.

What makes a meaningful interaction?

The concept of what is meaningful in education finds its roots in Ausubel's theory *of meaningful reception learning* and the idea that more inclusive concepts subsume less inclusive ones (McMeen & Templeton, 1985). According to this theory, we tend to store the general, more important aspects of a concept and forget the specific, less important details. What gets stored is what is meaningful. Meaningful interactions, therefore, might be seen as those activities that require the learner to access that meaningful knowledge in order to relate it to new information (Jonassen, 1988). The deeper the level of processing prompted by the interaction, the more meaningful it is.

Jonassen (1985) identifies five types of interactive program with each one representing a different degree of meaningfulness. He suggests that the lowest level of program is the *drill and practice* design as it typically demands only a shallow level of processing by the learner. *Tutorial* designs tend to produce more meaningful interactions, although the opportunity for the learner to relate prior knowledge to the new information is not always provided. *Problem-solving and simulation* designs require that learners apply previous knowledge to a new situation. These designs tend to employ interactions that are highly meaningful as the level of mental processing required is substantially increased. The most meaningful interactive design is the *intelligent or mixed initiative, knowledge-based system.* In this system, natural language processing is enabled to make it easier for the learner to relate to prior knowledge and the system learns from the learner in order to expand its own database of knowledge.

Establishing the right context can also help to produce meaningful interactions (McMeen & Templeton, 1985). Through the use of advance organizers, analogies and comparison-contrasts, designers can help learners access the appropriate knowledge from their memory in order to integrate it with the new information being presented (Jonassen, 1988).

Quality vs. quantity

Two of the most important, yet difficult assessments to make when it comes to interactivity are those of *quality* and *quantity.* Bork (1982) identifies three measures for the quality of interactive multimedia: the type of input required of the learner during the interaction, the program's method of analyzing the response, and the action taken by the program after the input (i.e. feedback). As was mentioned earlier, the deeper the level of cognitive processing required by the learner's input, the higher the quality of the interaction. Similarly, if feedback (Bork's third measure) is appropriately detailed and individualized, the learner will likely perceive the program to be more interactive. Bork's second measure, the program's method of analyzing the learner's response, is dependent on the branching characteristics of the program.

Interactivity in multimedia programs is based, primarily, upon two forms of branching: a multiple choice response or a free form response (Weller, 1988). Multiple choice items can be useful for discrimination tasks or for lengthy responses by the learner. They may take the direct form of a multiple choice question or they may come disguised as a matching, true or false, or drag and drop activity, Free-form or open ended responses correspond more directly to the real world and are, therefore, preferred over multiple choice items (Bork, 1992). For free form responses to truly simulate a student-tutor interaction, however, they tend to require elaborate planning and programm ing so that they may recognize a variety of correct and incorrect responses.

The quantity or degree of meaningful interactions in a program is another important aspect of overall interactivity. A program that asks only a single question over an extended period of time might be described as having a low degree of interaction.

By contrast, a program that frequently requires the learner to respond to questions would demonstrate a higher degree of interaction. For the learner to remain actively involved in the learning process, multimedia programs should demonstrate a high degree or frequency of interactions. Unfortunately, a practical measurement for neither quantity nor quality has been developed for designers to be able to apply.

Engagement and immersion

To be introduced to the concepts of engagement and immersion, one only needs to envision the intrinsically motivated youngster who is so enamoured with the recent acquisition of Myst™ that he/she is oblivious to all else around him. What is it that captures our full attention and motivates us to remain with a multimedia program? According to Jacques, Preece and Carey (1995), *engagement* is actually a combination of things - content, media (including type, presentation and controls) and the tasks required by the program. Together, these factors determine how engaging a program will be for the end user.

In a similar vein, Bishop and Cates (1997) describe *immersion* by drawing the analogy between a learner who is immersed in a programmed environment and a rolling cart on an inclined plane. Once the cart overcomes initial friction, it begins to roll. Once it's rolling, it achieves momentum and an inertia that makes it difficult to stop. In the same way, a learner might need to overcome some disinterest or dislike for computers or perhaps for the content of the program they are exploring. Once she becomes immersed, however, she attains a "state of flow". She finds herself drawn to the various features of the program and chooses to remain in the program's environment solely for its intrinsic rewards.

In both cases, although not identified as a unique contributor, interactivity plays an important role. It is hard to imagine a program that is highly engaging or immersive without it demonstrating both a high degree and quality of interactivity. By the same token, it seems likely that interactive programs with a relatively low quality and quantity of interactions, will be less than successful when it comes to engaging or immersing their audience. For this reason, designers might do well to shift their focus from creating interactive products to creating products that engage and immerse their learners. Of course, our definitions of "engagement" and "immersion" would have to be clarified and made measurable in order for us to avoid the same fate that has resulted with the term "interactive".

Designing for Interactivity in Closed Systems

The following considerations are a combination of advice gleaned from the literature on interactivity in multimedia and the author's personal experience as a designer of multimedia programs.

1) While the instructional design process is highly iterative with the sequence of steps being visited and revisited in various orders, you should ensure that your design of effective interactive strategies determines your selection of interactive technologies and not vice versa.

2) Include context in your interactions through the use of advance organizers, analogies and metaphors to allow learners to more easily relate their previous knowledge with the new instruction for example, in the simulation of operating an electronic device, provide the learner with realistic controls and sound effects to allow for previous knowledge to be applied. A changing cursor might also be employed so that when certain parts of the simulated device are passed over, appropriate actions are suggested. An example of this is the cursor changing to a *grabber* style hand when a slider type of control is to be manipulated.

3) Consider the level of mental processing demanded by your interactions. The deeper the level of processing that the learner is required to perform, the more meaningful the interaction for example, based on Bloom's taxonomy, *knowledge* type questions might require only a point and click response, while an *application* level of questioning might require learners to manipulate items on the screen to show their understanding of sequence within a logical process.

4) Consider the age and ability of your target audience. What might be a meaningful interaction for one group (e.g. *Just Grandma and Me* for pre-readers) may be less meaningful for a more advanced or experienced group.

5) Simulate two-way communication as closely as possible by performing a thorough learner analysis, accepting learner responses in a manner that best matches the task at hand, and providing specific, individualized feedback when appropriate.

6) Consider your content carefully. Some content lends itself more easily to interactive opportunities for example, a Physics course offers

potential for the simulation of manipulating simple machines to demonstrate an understanding of the principles and forces involved.

7) Strive to create an engaging, immersive environment through the use of meaningful interactions.

A Final Word

The overuse of the terms "interactive" and "interactivity" by today's educators and instructional designers has resulted in a increasing level of uncertainty and even discomfort as to what the words really mean. This is particularly true when the terms are used to describe closed-system instructional multimedia programs. Although components of interactivity can be identified, we have not yet developed any practical measurements of what constitutes meaningful interaction. Until these measures exist, instructional designers might do well to regain a perspective on what interactivity really means and to become more critical in their use of the term "interactive" when describing their programs.

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An Investigation ofthe Perceived Quality of Digital Media: Research and Research Design Issues

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Abstract: This article reports three experiments which tested the perceived quality of digital images, and discusses issues about conducting research into questions about technical quality in multimedia. Various quality settings are commonly available to multimedia developers, with dramatic effects on the file sizes and consequent loading and execution time in multimedia, yet little is known about whether viewers perceive the differences among different quality settings. Generally speaking, we have found and replicated evidence that for medium speed computers (60-80 Hz), digital video can be recorded and used at 10 fps, at a significant savings in storage space, and with positive effects on the perception of users. For still pictures, it is clear that users prefer larger pictures, and 32 bit color for large images. The results are less clear for 8 and 16 bit images, but there is some evidence that 16 bit images can be used with smaller images with little or no loss to perceived quality. There seems to be an interaction between the detail of images and preferred bit depth of color. For smaller images, greater bit depth was positively correlated with perceived quality. For the image with less detail, 16 bit color was highly preferred, and 32 bit color less preferred. Comments from participants revealed that most were cueing on resolution in still images, and on smooth motion and synchrony in video images for making their selections.
The second part of the paper discusses issues around conducting this type of research, including decontextualization, selection of variables and their values, and presentation protocol for treatments.

Resume: Cet article rend compte de trois experiences qui ont mesure la qualite per9ue d'images numerisees, et discute de problemes concernant la conduite de recherches sur des questions portant sur la qualite technique dans le multimedia. Plusieurs niveaux de qualite sont couramment disponibles pour les concepteurs en multimedia, niveaux qui influencent dramatiquement la grosseur des fichiers, et consequemment le temps de chargement et d'execution de l'application multimedia; par contre nous en savons peu sur la capacite des utilisateurs a percevoir les differences parmi les niveaux de qualite disponibles. De facon generale. nous avons demontre au cours d'experiences repetees, que pour un taux de regeneration de 1'image de 60 - 80 Hz, un video numerise peut etre enregistre et vu a 10 tps (trames par seconde), avec une economie d'espace memoire appreciable, tout en ayant un effet positif sur la perception des utilisateurs. Pour les images fixes, il est clair que les utilisateurs preferent des images plus grandes, et avec une profondeur de couleur de 32 bits pour les grandes images. Les resultats sont moins clairs pour les images 8 et 16 bits, mais il est assez evident que les images 16 bits peuvent etre utilisees pour de plus petites images avec peu ou pas de perte de qualite per9ue. II semble y avoir une relation entre le degre de details des images et la profondeur de couleur preferee. Pour les images plus petites, une plus grande profondeur de couleur est en correlation directe avec la qualite percue. Pour les images comportant moins de details, une profondeur de couleur de 16 bits etait de loin preferee. tandis qu'une profondeur de 32 bits 1'etait moins. Les commentaires des participants ont revele que la plupart determinaient leur choix a partir du degre de resolution pour les

images fixes, et a partir du mouvement sans a-coups et la synchronicite pour les images video.
La seconde partie de cet article discute de problemes poses par la conduite de ce type de recherche, incluant la decontextualisation. la selection des variables et leurs valeurs, et un protocole de presentation des images.

Introduction

This article has two purposes. The first is to report the results of experiments on the perceived quality of digital pictures and movies. For these experiments, we chose commonly available computers and common settings for digitizing media, most often those settings which production programs used as defaults, rather than build treatments using high end technology and esoteric production approaches. It is possible to create better digital media by using expensive hardware and through judicious selection of compression alogrithms, but few users have the resources or knowlege necessary to take advantage of these improvements. We wanted to investigate how typical quality selections influenced the perception of viewers. In the second part of this paper, we will discuss several issues researchers must grapple with when conducting experiments to assess the perceived quality of still pictures and digital video in multimedia-issues such as how to define quality, how to select and categorize independent variables, and whether multimedia quality should be assessed in a decontextualized or contextualized treatment. In this way, we hope to throw some light on the tradeoffs which seem to be inherent when treatments are designed to compare multimedia quality variables.

Multimedia Quality Experiment

One problem multimedia designers face when using graphics and movies is the size of picture files. Large files create storage problems, and in some cases they take an inordinate amount of time to load, and therefore cause programs to execute slowly.

There are two ways to reduce the size of picture files: reduce the size of the image; or, reduce the number of colors (bit depth) when creating the files.

Color can be represented at different bit depths, although 8 bit (256 colors). 16 bit (thousands of colors) and 32' bit (millions of colors) are typical choices. Adjustments to either of these variables will affect the quality of the image when it is displayed on screen. Whether or not the quality difference is perceived, and whether the increased file size and loading time is worth the concomitant increase in perceived image quality is often a difficult judgement to make.

A study of the perceived quality of digital still pictures and movies (Schwier and Misanchuk, 1996a) suggested that quality (in the eyes of the learner) may be reflective of technical superiority for larger pictures (640 x 480 pixels), but not for smaller ones (320 x 240 pixels). Viewers generally preferred larger still pictures to smaller ones, and for larger pictures, they preferred those with higher bit depths (see Figure 1). The exception was with small pictures, where those with 16 bit color were preferred to either 8 or 32 bit color in the same size. In fact, the 16 bit,

For 32 bit color, Macintosh systems actually use 24 bit color, but some software packages refer to it as 32 bit. We caution the reader that the actual bit dipt is different than the label suggests.

smaller picture was also preferred to every picture other than the large, 32 bit color rendition. The investigators speculated that this may have been the result of an optimal resolution match between the monitor setting and the bit depth of the picture. The picture used in this experiment was a full color portrait, selected because it had a wide variety of hues and the background had a subtle gradation of value from dark to light[2] .

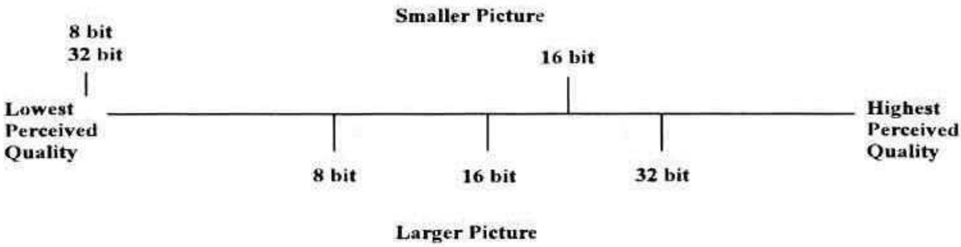

Figure 1. Thurstone Scale of preferences of digital pictures at two size settings and three bit depths of color from Schwier and Misanchuk (1996a).

We questioned how the treatment may have influenced the results of this experiment. Given that it was a portrait used in the treatment, we wondered whether it might have invited subjects to focus on different aspects of the photograph when making their choices. One subject may have preferred a soft focus, another might have preferred clear expressions, and another may have liked a posterized effect on the background. Subjects were not asked how they were making their decisions, so there was little solid guidance available for interpreting the results.

Movie files present similar difficulties to an instructional designer. Large movie files require substantial storage space, and with some applications, large movie files take a great deal of time to load and play within an application.

There are two ways to reduce the size of movie files:

1. reduce the size of the movie window; or
2. reduce the number of frames/second of the recording.

Movies can be recorded in various window sizes, including quarter (160 x 120 pixels), half (320 x 240 pixels) and full screens (640 x 480 pixels). They can also be recorded at any speed up to 30 frames per second (fps), which is the standard rate for NTSC video playback. Each frame of video requires additional file space, so the greater the number of frames per second, the greater the resulting file size. But there is a further complication. Unless fairly sophisticated, high-end production software and hardware is used, computers cannot record 30 frames per second. Indeed, even if recorded, few computers are capable of playing back larger video windows at 30 frames per second.

[2] The photograph can be viewed at: http://www.extension.usask.ca/PapersyMisanchuk/AECT97/Photol.html

Adjustments to either of these variables (window size, frames per second) may also reduce the perceived quality of the image when it is displayed on screen. The viewer may not be able to see a satisfactory amount of detail in smaller windows, and using larger windows may result in a choppier, less fluid display of motion. At the present time and under almost every condition, digital movies are poor in quality. They also demand large file sizes, rendering them slower to load onto screens.

For digital movies (see Figure 2), viewers seemed to favor larger windows (320 x 240) over smaller windows (160 x 120). Frames per second also appeared to be an important variable, but in a counter-intuitive way. Generally speaking, recordings made at lower frame rates were preferred to recordings at higher frame rates. This held for both larger and smaller window sizes (Schwier and Misanchuk, 1996a). The researchers speculated that the lower frame rates more closely matched the processing speed of the computers, resulting in the impression of more fluid, less choppy, movement. The video clip used in this experiment was a fairly monochromatic sequence of a pelican swimming, flying and eating fry in a river, beneath an overflowing weir; there was no accompanying audio. The movement on the original videodisc was fluid and multidirectional, and it contained several visual details[1].

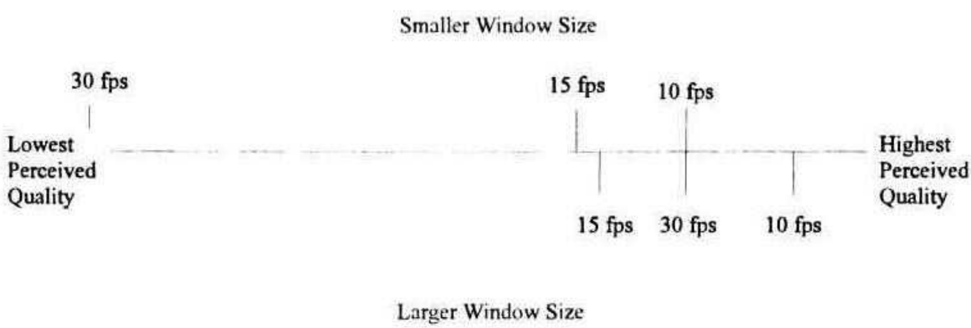

Figure 2. Thurstone Scale of preferences for digital movies at two size settings and three frames per second settings from Schwier and Misanchuk (1996a).

We were unable to find any other research which addressed the influence of these variables on the perceived quality of pictures and movies in multimedia, so we designed an experiment to refine some of the variables, replicate this study and determine the actual costs and perceived quality differences when the window size and bit depths of pictures are changed and when the window size and frames per second of a digital movie are manipulated.

Research questions

How will larger and smaller pictures compare in file size and perceived image quality?

3 The video can be viewed at: http://www.extension.usask.ca/Papers/Misanchuk/AECT07/Video1 .html

How will altering the bit depth of images influence their file size and perceived quality?

Will a picture which contains a high degree of detail be rated differently than a picture which contains significantly less detail?

How will larger and smaller movie windows compare in file size and perceived image quality?

How will recording digital movies at different frames per second influence their file size and perceived quality?

How will subjects describe the variables they considered when making comparisons?

Subjects

Thirty adult employees and educational technology students at the University of Saskatchewan volunteered to participate in the study.

Treatments

To measure perceived picture quality, two full-color photographs were scanned on an HP ScanJet II cx/T at its highest quality settings, one photograph for each of two matched treatments. Speculating about the results from the pilot study (Schwier and Misanchuk, 1996a), researchers questioned whether the amount of detail in the original treatment provided the strongest cue for making quality discriminations. For the two treatments in this experiment, one treatment employed a reproduction of an impressionist painting, Bathers at La Grenouillere by Claude-Oscar Monet, which had little precision and detail, but a full range of color (Roland, 1996). The second treatment employed a photograph of the interior of the National Gallery of Art in London, a photograph which contained a high degree of detail in addition to a full range of color (Roland, 1996).

For each treatment the scanned photograph was imported into Adobe Photoshop(™) to create six versions of the picture, including two image sizes (640 x 480 pixels and 320 x 240 pixels) and three bit depths of color (32 bit, 16 bit, and 8 bit). Each was saved as a PICT file without any type of compression algorithm. Each image was imported into a program created with Authorware Professional™) v. 3.5, and a series of "pages" created to provide a paired comparison of every possible combination of image variables for each picture. The order of comparison was constructed according to recommendations by Ross (1934) for conducting paired comparisons to eliminate effects of picture location and presentation order. A Thurstone Scale was constructed for comparing resultant data (Torgerson, 1958).

To measure perceived movie quality, six versions of a 30 second clip of video were digitized as QuickTime™ movies. The original video was recorded on a Sony Betacam™ and transferred to videodisc. A segment was chosen which had few colors (to reduce possible contamination from this variable) but a great deal of motion which was, in this experiment, accompanied by a synchronized sound track (with key fram synchronization at half-second intervals). The segment was a

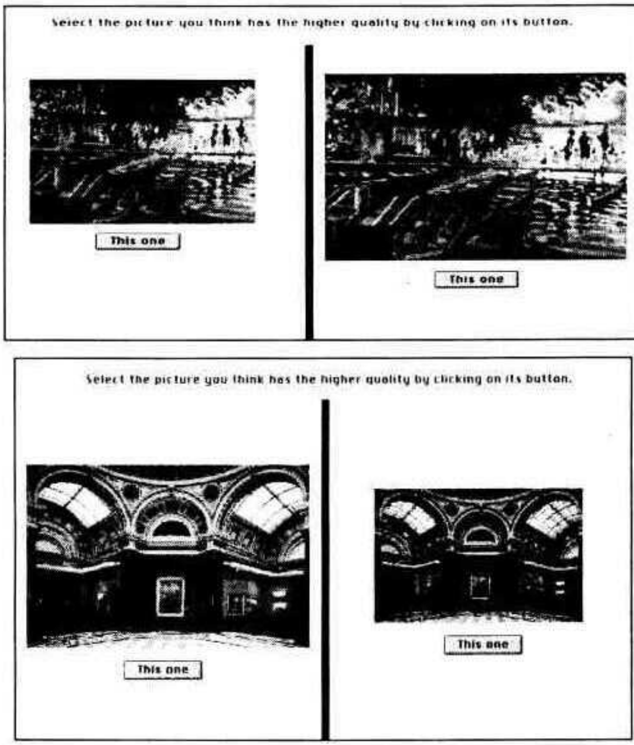

Figure 3. Screen samples from the picture quality experimental treatments. The photographs can be viewed at http://www.extension.usask.ca/Papers/Misanchuk/AECT97/Photos2.html

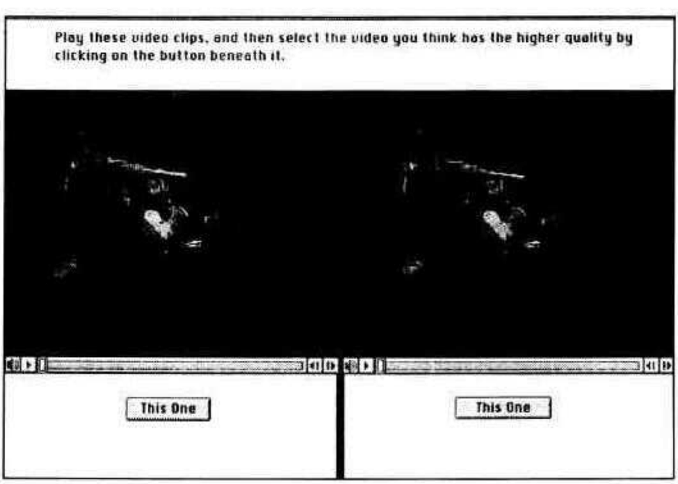

Figure 4. Screen sample from the movie quality experimental treatment. The video can be viewed at http://www.extension.usask.ca/Papers/Misanchuk/AECT97/Videol.html

a farcical dance scene from the puccini opera La Boheme (Hofsteter, 1986), originally recorded to videodisc at the University of Delaware. One of the reasons we selected this segment was because the sound track and dance provided a strong indication of the stability of the synchronization between sound and picture, a feature that was missing in the original pilot study. The digital versions were recorded in quarter screen (160 x 120 pixels) and half screen (320 x 240 pixels) sized windows, and three settings of frames per second (30, 15 and 10 fps) using Apple's Fusion Recorder™ 1.0.2 on a Power Macintosh™ 8100/80AV with 32 Mb of RAM and 2Mb of VRAM. Each movie file was imported into a program created with Authorware Professional v. 3.5 and a series of "pages" were created to provide a paired comparison of every possible combination of movie variables under study. The order of comparison was constructed according to recommendations by Ross (1934) for conducting paired comparisons to eliminate effects of picture location and presentation order. A Thurstone Scale was constructed for comparing resultant data (Torgerson, 1958).

The treatments were administered on two matched Power Macintosh 6100/60AV computers running under System 7.5.5 with 15" Apple Audioscan™ monitors. Headphones were worn for the audio portion of the treatment.

Each subject completed the treatments individually and without consultation. Subjects were asked to compare pairs of images and movies as they appeared on the screen, and judge which image or movie had the higher quality. No definition of the term "quality" was offered: subjects were instructed to employ their own definitions of the term. Selections were made by clicking on buttons beneath each image or movie (see Figure 3). The movies remained on the screen until a selection was made, and both clips remained under the complete control of the subject. They were able to adjust the volume on either clip independently, and they could select and replay portions of the clips and still frames as many times as they wanted.

At the end of each treatment, subjects were asked to describe the criteria they used to make their judgements about quality. They typed their responses, and their comments were saved along with the paired comparison data.

Results (still pictures)

The paired comparisons data were used to construct a Thurstone scale. Figures 4, 5 and 6 are graphic displays of the Thurstone scale points for the picture and movie treatments. One of the advantages of Thurstone scaling is that it provides a method for representing distances meaningfully. Graphically, it is easy to describe the relative positions of the quality ratings. The values and rank orders of Thurstone scale points are presented in Tables 1, 2 and 3 (1 =highest perceived quality rating, 6=lowest perceived quality rating).

File sizes of the picture and movie files were obtained from the "Get Info" system function on Macintosh System 7.5.5.

Table 1: File sizes and quality ratings for treatment with lower amount of detail at two sizes and three bit depths of color.

Window Size and FPS	Movie Size (Mb)	Thurstone Scale Point	Thurstone Scale Ranking
640 x 480 (32 bit)	1528	5.07	1
320 x 229 (32 bit)	876	-3.52	6
640x480 (16 bit)	1039	-1.51	4
320x240 (16 bit)	600	1.46	2
640 x 480 (8 bit)	430	0.92	3
320 x 240 (8 bit)	266	-2.42	5

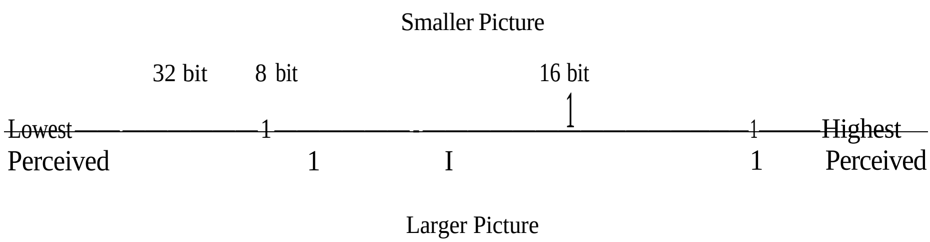

Figure 4. Graphic representation of Thurstone scale points for picture treatment with lower level of detail in the picture at two sizes and three bit depths of color.

For larger pictures in the lower detail treatment, there was a clear preference for the image with the greatest bit depth of colour. Curiously, the 8 bit version of the image was preferred to the 16 bit version of the same picture.

For smaller pictures in the lower detail treatment, bit depth of colour seemed to have little to do with the quality ratings given the pictures. The similar low ratings of smaller 8 and 32 bit pictures could indicate that the two images are inseparable visually. This is not likely, however, given that the smaller 16 bit picture had a higher quality rating than the other two smaller pictures. This unexpected finding was similar to the original finding in the pilot experiment (Schwier and Misanchuk, 1996a), and the difference between these results and the results of the second treatment seems to support our suggestion that this treatment, with its lower level of detail, was similar to the portrait used in the pilot study. At that time, we speculated that there may be an optimal colour depth for different size images, one which takes maximum advantage of the colours available. It could also be that picture size is so influential that the companion variable (bit depth of colour) is virtually ignored. The replication of this finding lends support to these speculations, particularly for images judged to have lower levels of detail or precision.

Table 2: File sizes and quality ratings for different size pictures and different bit depths for treatment with higher amount of detail.

Window Size and FPS	Movie Size (Mb)	Thurstone Scale Point	Thurstone Scale Ranking
640x480 (32 bit)	1313	1.95	1
320 x 229 (32 bit)	716	-0.80	4
640 x 480 (16 bit)	890	0.47	3
320 x 240 (16 bit)	487	-0.89	5
640 x 480 (8 bit)	383	0.56	2
320 x 240 (8 bit)	210	-1.29	6

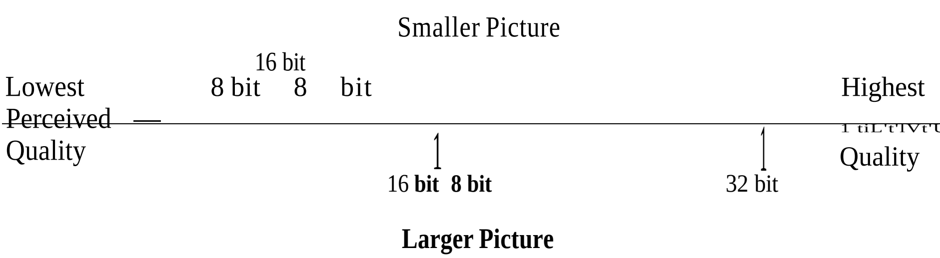

Figure 5. Graphic representation of Thurstone scale points for picture treatment with higher level of detail at two sizes and three bit depths of color.

Generally speaking the Thurstone scale suggests that for larger and smaller pictures, where detail and a high degree of precision is important, the higher bit depth setting is desirable. For 8 and 16 bit images, there appears to be an interaction between image size and bit depth of color. For larger pictures, there appears to be little difference between 8 and 16 bit images. For smaller pictures, there appears to be a preference for 16 bit images over 8 bit images. One might speculate that with larger images, the role of bit depth was less influential for discerning details in the pictures than the size of the picture. For smaller images, greater bit depth may appear to compensate for some of the detail lost by size. This position is bolstered somewhat by the observation that there was a clear preference for larger pictures in the higher detail treatment, with the smaller 16 bit image providing an interesting anomaly.

Comments from subjects cast some light on the data. First of all, it was clear from their comments that subjects attempted to compare the pictures carefully and systematically.

> I tried to select the picture that had the sharper edges and outlines initially. When I could not seem to see much difference in this quality I pay particular attention to the light coming in through the ceiling windows and also the spotlights on the portraits. It seemed that when it was particularly difficult

> to choose between the two, the only way I could decide was through this quality of "light", (subject)

A number of comments indicated that the participants were able to identify different bit depths of color, even though it was articulated in different ways. It was apparent that for the most part, shallower bit depth was interpreted as louder, more garish color. Greater bit depth gave the impression of more natural, pleasant color.

> I also prefer smooth lines and less bright colours as opposed to bright colours and a more digitized look, (subject)

> If I see nothing but bold colours and no in-between colours then I suspect that the picture has no colour depth. The best way I have of telling is to look at a colour that changes shade with distance. The reasons for this is that jagged edges and bold garrish [sic] colours are HARSH! Smooth lines and mellow colours are pleasing, (subject)

> On the orange wall, you could see sometimes the shading change abruptly, (subject)

> Once posterization sets in, except for special effects, these were automatically rejected. (subject)

> I also looked at whether or not the picture looks realistic or like a "computer generated" image. The final aspect I took into account was the shading of the colors. (subject)

There was a great deal of commonality among subjects about what they were cueing on to make selections. Most were looking for clarity, sharpness, and detail- all different terms which we would probably combine under the label "resolution." This seemed to be the preferred variable, regardless of the type of picture.

> When I was making a selection, I was looking at the detail in the boats, the color clarity and the sharpness of the people and objects in the picture. (subject)

> I also paid particular attention to the rowboats in the foreground of the painting and also the reflections in the water. I found that these particular parts of the painting were affected quite significantly in the specific examples. when the color and line quality were blurred or less sharp I was able to make the easiest decisions. (subject)

> I was looking for picture clarity. Crisp detail in the paintings caught my eye. (subject).

The last subject quoted above pointed at the second most often mentioned element - size. All other things being equal, most subjects seemed to prefer larger pictures.

> Size didn't seem to matter but where 1 could not decide I believe I chose the larger picture. (subject)

> I picked those that appeared clearer, crisper, sharper... once again. Where they appear equal, I picked the larger image. (subject)

> I like bigger pictures... no logic at all... went with the gut reaction.... (subject)

> Also, if the "quality" looked the same to me. I chose the bigger picture because I think this one would be harder to achieve. (subject)

> If they appeared to have the same compression ratio 1 chose the larger one because it offered more detail. (subject)

But there was a curious counter point to this perspective. A few subjects occasionally selected smaller images for very specific reasons. Sometimes the reasons revealed a misunderstanding of the medium employed.

> My primary focus was on picture clarity, but where both pictures seemed equal I always picked the larger. In the case of a smaller, clear picture vs a larger pixelated images I always chose the smaller. Interestingly enough, when both small and large pictures were pixelated I prefered the smaller as it seemed to hide the imperfections soemwhat better. (subject)

> In the very first example of different sized photos I saw little or no difference and choose the smaller (just to save on printing costs). (subject)

It was interesting to note that subjects did. on occasion, approach the two different pictures (higher detail vs. lower detail) quite differently. When we designed the experiment, we felt that this might be a significant issue, and a few comments supported that position.

> It was much harder to choose a "higher quality" sample in this section because of the style of the picture. A photograph is easier than an Impressionist painting! I looked for clarity and fuzziness, focussing on the woman (on the left of the trio) in the right side of the painting, the boats, and mainly the leaves on the trees. But I wouldn't dare tell an Impressionist that clarity = higher quality... (subject)

> For some reason, these pictures seemed more clear when they were smaller. I think this is because the picture itself is one in which the objects do not have very definite lines. In these types of pictures, the smaller the picture the clearer they seem to be. In the first set of pictures (the ones of the inside of the art museum) the objects were created with very definite lines and the larger they were, the clearer they seemed. (subject)

Results (video)

For digital video, it appears that the frame speed of the video is more important than the size ofthe window (see Table 3 and Figure 6). Subjects, on the whole, preferred the smaller images, with the exception of the large frame recorded at 10 frames per second. The computers used in this instance were evidently not able to process the higher frame rates (15 or 30 fps) with the larger window; something less than that was actually displayed. They were, however able to process 10 frames per second with the larger window, and came closer to keeping up with all of the frame rates of the smaller window. We speculate that the resultant similarity between the recording rate and playback rate may result in a more fluid appearance to the displayed video. Where the larger and smaller versions were both "fluid," the larger window was preferred.

Table 3: File size and quality ratings for digita video at two window sizes and three fps (frames per second) settings.

Window Size and FPS	Movie Size (Mb)	Thurstone Scale Point	Thurstone Scale Ranking
Quarter (30fps)	11.488	1.74	3
Half (30fps)	41.411	-3.90	5
Quarter (15fps)	6.126	4.42	1
Half (15fps)	20.683	-4.00	6
Quarter (l0fps)	4.092	-0.11	4
Half (l0fps)	14.329	1.85	2

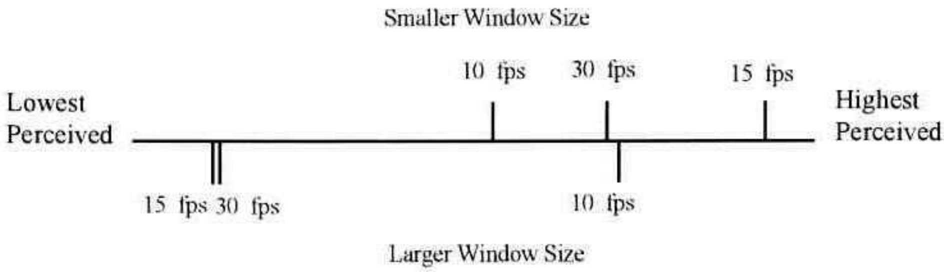

Figure 6. Graphic display of Thurstone scale points for digital video at two window sizes and three-fps (frames per second) settings.

Comments from the experimental subjects supported this interpretation of the data. Subjects grappled with the way the treatment was administered. There were two clips on each screen, and a number of decisions were required for participants to make comparisons. We noted that subjects took considerably longer to arrive at their judgements on the video segments than they did on the still pictures. For each clip, volume had to be controlled, and the video might be started, stopped and positioned for purposes of comparison. This meant that different subjects developed unique strategies for analyzing the data. This may have contributed some contamination to the way(s) video clips were analyzed.

> I first watched the pushing off the knee bit (in the clip on the left) to see if there was blurring of the sleeve as the fellow fell. Then I watched that same two-second bit in the second video, then let the second video run had the kerchief putting-on. Then I stopped the second video and went back to the first to watch the pushing to the kerchief bit. Usually by that time 1 could tell which I thought was clearer, less choppy, more fluid, and had less blur. If in doubt, I would continue watching, or rewind and compare the first scenes. (subject)

At the same time, and all other things being equal, most subjects cued very deliberately on the fluidity and how closely the video and sound were synchronized.

> The major factor I used in evaluating the video segments was the flow or frame rate of the video. If the video was choppy I did not like it. Again the smaller the window the better the frame rate appeared. The actual digital quality of the picture was not as important as the was the action moved. (subject)

> I tended to pick the bigger pictures when I couldn't decipher a change in the audio. (subject)

> The jerkiness of the movement was the key factor. When the one actor pointed his toes in time to the music, you could catch how smooth it looked. Also, when the actor's knee struck the floor, often the sound would be out of sync. The smaller image was able to display more frames per second than the larger one. The smaller of the two always was better (in my opinion). (subject)

Any difference in apparent audio synchrony would probably be an artifact of the computer speed - its inability to keep up with the frame rate. For QuickTime video, audio is always given priority for smooth playback, with video display adjusted to keep pace with the audio. Key frames are set in digital recordings to establish specific points to resynchronize the audio and video. For the experiment, key frames were recorded at half-second intervals, so if the video displays on the treatments were able to keep pace with the audio in all cases, the synchronization would be identical for all treatments. The perceived lack of synchrony in some clips indicate that the computers were unable to keep pace with some of the video segments.

At the same time, the data suggest that synchrony of audio and video may indeed be a critical factor in determining the perceived quality of video. When video has low fidelity (is choppy and indistinct), as is the case with most digital video, it is often very difficult for the viewer to determine which treatment is worse. At these times, the viewer looks to synchrony to make a judgment of video. it is often very difficult for the viewer to determine which treatment is worse. At these times, the viewer looks to synchrony to make a judgment of quality, and this is consistent with other research which suggests that synchrony of audio and video is an important variable in how people evaluate media, whereas video fidelity appears to be insignificant (Reeves and Nass, 1996).

Conclusions

Clearly more investigation is needed before robust guidelines can be formulated to help designers choose optimal (as opposed to maximal) size, colour depth, and frame rates. For the moment, file size and the initial findings reported here can be used as guides, but we caution designers to generalize these findings carefully. Generally speaking, we have found and replicated evidence that for medium speed computers (60 - 80 Hz), digital video can be recorded and used at 10 frps, at a significant savings in storage space, and with positive effects on the perception of users. For still pictures, it is clear that users prefer larger pictures, and 32 bit colour for large images. The results are less clear for 8 and 16 bit images, but there is some evidence that 16 bit colour can be used with smaller images with little or no loss to preceived quality. For smaller images, there seems to be an interaction between the detail of images and preferred bit depth of colour. For those images with more detail, greater bit depth was positively correlated with perceived quality. For those images with less detail. 16 bit colour was highly preferred, and 32 bit colours less preferred - a finding that was consistent with the earlier pilot study (Schwier and Misanchuk, 1996a).

Research Issues

A host of questions and issues face researchers studying the quality of multimedia. As we went through the process of designing and conducting this and a previous series of studies, we grappled with and learned from a number of issues we believe will help other researchers interested in conducting similiar research about the quality of multimedia images, particularly questions about the perceived quality of digital images by users (Schwier and Misanchuk, 1996a. 1996b).

Definitions of interactive multimedia and quality

A definition we have used previously describes interactive multimedia instruction (IMI) as "an instructional program which includes a variety of integrated sources into the instruction with a computer at the heart of the system" (Schwier and Misanchuk, 1993, p.6). It is a fairly common definition and one which is similiar to other definitions of **M** (c.f., Gayeski, 1993; Schroeder and Kenny, 1995).

But the most elusive element to define is quality. Do we examine the quality of the contribution made by multimedia to instruction? Do we study the quality of aesthetic decisions made in screen design? Deo we examine technical quality of the multimedia elements? Certainly all of these issues, and more, are important in a comprehensive study of interactive multimedia instruction, and any path chosen will impose a series of very different demands on the researcher.

For these experiments, we chose to examine technical quality in isolation, and to the exclusion of most instructional or aesthetic considerations. The defintion of technical quality may be approached from at least two different perspectives: perceived technical quality and actual technical quality. In these experiments, we emphasize perceived technical quality; that is, how adequate is the still picture and the digital video in the opinion of the viewer? This was contrasted with assumed technical quality. For example, video recorded at 30 frames per second was assumed to be of higher quality than video recorded at 15 frames per second.

One measure of perceived technical quality in digital video is how smooth the motion appears to be to the viewer. Digital video is notoriously choppy, and can be very distracting to a viewer who is used to high-quality, commercial video. How should video clips be selected which emphasize the technical characteristics under study? It it simportant to use material which samples the range of technical qualities under scrutiny, but doesn't introduce extraneous variables. For example, in the quality experiments reported here, we selected a video clip which contained almost continuous motion, and had motion running in several directions simultaneously. We knew that motion was a critical variable, and therefore wanted to make sure that we selected a clip which included more than one type and direction of motion, but we also selected a clip that was relatively monochromatic, because we didn't want to emphasize the influence of color in the experimental treatment of video, we were concerned that subjects might be attracted to (or distracted by) particular colors or combinations, or that certain colors might act as contaminants to other motion variables. For instance, a dancer wearing a red sweater who is moving rapidly from one side of the picture to another might cause some flaring of the color which would be interpreted as a problem with the technical quality of the digital video.

There are also actual measures of technical quality, typically represented by increasing file size. File size is an easily obtained technical measurement, yet one which is not less important to instructional designers than perceived quality, due to the intrusive influence of large files on the storage and execution of computer-based instruction. Large files require huge areas for storage, and with many multimedia authoring tools, large image and movie files execute very slowly.

Variable and value selections

Two variables were included in the digital video experimental treatment reported earlier in this paper; window size and frame rate. These were chosen because they can have a profound effect on file size and execution of the clip. Other variables, such as key frames, the compression algorithm (CODEC), and audio quality may be important when audio accompanies the video segment. Key frames are used to synchronize audio with video (the greater the number of key frames, the higher the degree of synchronization).

Should audio be included in video treatments? In most cases, of course, audio is an integral part of a video segment. However, for testing the perception of video quality, we questioned whether audio might be a contaminating variable because of its interaction with a visual. One needs only to view a popular film with and without the audio track to experience how dramatically audio can influence the interpretation of the visual.

result, we chose to study only the visual in video for the earlier experiment (Schwier and Misanchuk, 1996a). But for these studies, we included audio because we wanted to test typical treatments that use the types of settings most developers might employ, and we speculated that developers will most commonly digitize video that has an audio track. Our studies suggested that the synchrony may in fact be an important feature used by viewers to judge the perceived quality of video. Several experimental subjects commented on their attempts to match the timing of the dancers to the timing of the music on the audio track to make their decisions about which video was best. This supports other recent research that suggests that synchrony is not only important, it may be more important to the viewer than the actual quality of the visual (Reeves and Nass, 1996)

Full motion video is played at 30 frames per second. Logically then, when measuring the perceived quality of digital video, the highest quality setting should be 30 frames per second. However, most computers cannot play video at very fast frame rates, especially at larger window sizes, so is it reasonable to do comparisons at faster fps settings? We decided that it was important to record and test video at 30 frames per second, because developers are sometimes unaware of the limitations of computers, or intentionally record video at higher frame rates in anticipation of faster hardware in the near future - hardware which will be able to handle 30 fps video. We included fast frame rates in the experimental treatments in order to determine whether actual quality differences were perceived by viewers on typical multimedia computers of this generation. Other frame rates may be chosen randomly; we have no reason to believe one set of selections would be better than another. We chose to record segments at 15 frames per second and 10 frames per second. Fifteen frames per second was selected because it was close to the average rate of playback on the computer systems we used for testing. Ten frames per second is a very common setting used by multimedia producers, and it results in significant savings in file sizes.

We also speculated that larger movies might be more attractive to viewers than smaller movies, all other things being equal. In our experiment, we limited the different frame sizes (window sizes) to quarters and half frames. These are common sizes used in multimedia presentations, and any larger window sizes result in much slower compression/decompression of the images, which in effect dramatically reduces the frame rate at which video is recorded and played back. Original video which is digitized should be of the highest quality possible, so that any criticisms of quality in experimental treatments are not related to poor source material.

Still pictures share some characteristics with video, but present a strikingly different challenge to the design of an experimental treatment. We speculated, based on a pilot study, that viewers would assign higher quality ratings to pictures which were sharper and had a natural looking range of colors. So for the experiment, we selected pictures which included a wide range of colors and gradient lighting. Still pictures have at least two characteristics which may influence actual and perceived quality-window size and bit depth of color. These variables are easy to control when producing instructional treatments. High quality scanners allow the conversion of photographs into equally high-quality digital source material, and programs such as Adobe Photoshop(™) permit a researcher to accurately control the size, resolution and bit depth of a still image. The production of treatments is dependent on a system's ability to reproduce color, and upon the quality of the monitor, however, so care must be taken to produce and display materials on a system which is capable of creating the images you require. In our experiments, we started with very high quality photographic reproductions and scanned them at the highest quality settings available on an HP ScanJet II cx/T. These images were used as the source material from which we derived two commonly used picture sizes and three different bit depths of color to produce our stimulus materials.

We also confronted the issue of picture content. In the pilot study, a portrait was used, and we wondered whether the type of content could have influenced the results. Portraits don't typically emphasize detail, and can have a softer look than some other types of photographic images. So for these experiments, we first selected an impressionist painting with little detail and precision. The photographic reproduction of the painting captured the vibrant colours, but the style of the image was soft, sweeping and subtle. For a second experimental treatment, we selected a very realistic architectural photograph which contained a high degree of detail and a very sharp focus and depth of field. These two treatments stood in direct contrast to each other, and invited subjects to analyze the images differently.

Contextualized versus decontextualized presentation

It is difficult, yet important, to acknowledge and accommodate the context of multimedia instruction, while attempting to decontextualize technical assessments of quality. Multimedia assumes a context, primarily because anything that exists as part of a multimedia environment by definition coexists with other media. Should the treatments be presented to the subjects in an instructional module? Should the context for comparison be educational? Will it matter whether participants are entertainment media clups or educational media?

In interactive multimedia instruction, we are interested in how several component media converge and contribute to a complex symphony of instruction. But although we are interested in rich, contextual influences of multimedia, technical assessments of quality demand that we isolate characteristics of individual digital media. For example, the quality of a Quick Time movie can be measured reliably, but once the Quick Time movie is embedded in an instructional context, the learner's assessment of its technical quality may vary based on the learner's assessment of the instructional quality. So our position varies, depending on the dependent variable under study. If learning influence or potential is under scrutiny, then an instructional (or at least educational) context for the treatment is essential. If, however, strictly technical assessments are required, we believe it is important to decontextualize the treatment as much as possible, due to the potential contaminating influence of the instructional context.

Presentation and comparison

Should images which are being compared be shown side-by-side for direct comparison, or should they be shown individually, with the subject able to toggle bit depth of color). Many of us have experienced the "television showroom phenomenon" where a wall of televisions reveal a startling difference in picture quality among the various screens, whereas differences are much less apparent when one looks first at one screen and then at another. It is therefore important to provide an experimental context which invites such direct comparison of multimedia.

At the same time, it is impractical and unwise to compare all of the treatment images at one time. For one thing, it would be difficult to find a monitor large enough to display all of the images simultaneously for comparison while preserving the quality a viewer would experience while viewing a desktop monitor. Second, the order effect would be difficult or impossible to manage, as the perception of any single image would certainly be influenced by its position among the cluster of images being compared. Therefore, we recommend a paired comparison approach. In paired comparisons, each image is compared one at a time with every other image, and the viewer is required to select the image with the highest quality. The order in which pairs are presented to the viewer can be randomized, as can the relative positions of images on the screen.

When multimedia treatments are reported, it is important to describe in exhaustive detail the systems used for presentation of the treatment. Microprocessor speeds vary considerably, and can have dramatic effects on multimedia displays. Similarly, perceptual differences may be associated with monitor resolution, colour settings and brightness/contrast settings. When designing treatments, researchers need to consider the colour and clutter on the portion of the computer desktop or background which is showing. Further, where more than one system is used in an xperiment, it is very important for studies to employ matched systems with identical monitors, processors and operating systems.

Summary

Conducting research on the perceived quality of multimedia is difficult, not only because of the elusive nature of human perception, but because of the array of technical and contextual variables that can influence outcomes. Still, with careful attention to technical and experimental details, much can be learned about how viewers respond to various visual treatments, and within precisely defined contexts, inform the work of instructional designers working with multimedia.

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Integrating Information Technologies to Facilitate Learning: Redesigning the Teacher Education Curriculum

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Abstract: Research indicates that student teachers are frequently quite anxious about their use of, and graduate with limited knowledge of, learning technologies. Moreover, Teacher Education programs do not teach them to use these technologies. This paper describes a project to address this problem by integrating the use of learning technologies across the Teacher Education curriculum. We outline the change process used and report on the preliminary results of an evaluation of this process. Student and faculty attitudes were assessed at the beginning and end of the year using demographics and computer attitude questionnaires (Gressard & Loyd, 1986). Subsets of each group attended focus groups at the end of the year. Results indicated that, while faculty felt they had successfully integrated, students did not. Students criticized the self study approach to basic skills and stressed professors should have done more. These results pointed to several adjustments for Year 2.

Resume: La recherche nous indique que les etudiants-maitres sont souvent tres anxieux face a l'utilisation des nouvelles technologies en education et aussi qu'ils graduent generalement avec une connaissance limitee de ces technologies. De plus, le programme de Teacher Education ne comporte aucune formation sur l'usage de ces technologies. Cet article decrit un projet s'adressant particulierement a ce probleme en integrant l'usage des nouvelles technologies dans tous les cours du programme de Teacher Education. Le processus de changement qui a ete favorise et un rapport sur les resultats preliminaires de 1'evaluation de ce processus sont presentes. Les attitudes des etudiants et des professeurs ont ete evaluees au debut et a la fin de l'annee scolaire a l'aide de questionnaires sur la composition demographique et sur les attitudes face a l'ordinateur (Gressard & Loyd, 1986). Des sous-groupes d'etudiants et de professeurs ont participer a des groupes de discussions a la fin de l'annee. Les resultats demontrent que meme si les professeurs croient qu'ils ont bien integre les nouvelles technologies dans leurs cours, les etudiants croient que tel n'est pas le cas. Les etudiants ont vivement critique 1'approche autodidactique preconisee pour 1'acquisition des habiletes de base et ils ont aussi fait valoire que les professeurs auraient du faire plus d'effort. Ces resultats ont offerts des pistes pour de nombreux ajustements pour la deuxieme annee du projet.

Introduction

Faculty integrally involved in the teaching of learning technology in the University of Ottawa Teacher Education Program over the past five years, had been concerned for some time that this instruction had been happening in an isolated manner. Technology instruction consisted solely of two-credit (26 hour) directed courses focusing on technology and learning. Given the restricted time available, these courses concentrated on the basic skills of educational technology (mainly computing topics such as word processing, spreadsheets and databases) and were insufficient in scope to address the use of technology in the curriculum in any depth, a problem common to most Teacher Education Programs (Office of Technology Assessment, 1995).

The best way to resolve these concerns was to integrate technology across our Teacher Education curriculum and make it central to the Teacher Education experience. Integration seemed advisable for several reasons. First, the use of learning technologies has been strongly emphasised in the Ontario school curriculum (e.g., the Ministry of Education, 1995). Second, the Report of the Ontario Royal Commission on Learning (Begin & Caplan, 1994) listed Information Technology as one of the 4 engines of change to improve schooling. It seemed imperative that we prepare our student teachers to use technology effectively in their own teaching.

Research strongly indicates that new teachers tend to graduate with limited knowledge of the ways in which technology can be used in their professional practice and most Teacher Education Faculty do not teach student teachers how to use learning technologies (Office of Technology Assessment, 1995; Topp, 1996; Handler & Strudler, 1997). In response to this problem in the United States, the National Council for the Accreditation of Teacher Education (NCATE), in conjunction with the International Society for Technology in Education (ISTE), has developed foundational standards in the use of computing and technology in education for all teachers, a wide range of outcomes intended to guide teachers to use computer technology to facilitate teaching and learning (e.g., Wetzel, 1993; Todd, 1993; Thomas, Wiebe, Friske, Knezek, Sloan & Taylor, 1994; Pryor & Bitter, 1995). While our technology and learning course was based on the NCATE / ISTE foundations, we saw integration as necessary to place these outcomes in context and to produce teachers who are skilled at using technology as a standard tool of teaching and learning (Friske, Knezek, Taylor, Thomas and Wiebe, 1995-1996).

Finally, from experience with our own courses, from course evaluation comments and anecdotal evidence, we were aware that our student teachers were often quite anxious about their use of computing - a point verified in a recent study of our student teachers (Gabriel & MacDonald, 1996) - and easily frustrated with computer lab malfunctions. In particular, student teachers identified access to the crowded facilities and time in a busy schedule to focus on computing as major problems in the program (Gabriel & MacDonald, 1996). Integration could potentially reduce such anxiety and frustration by providing extended exposure and practice with computing within the context of Teacher Education courses, with support from faculty and staff. This paper describes our integration project, outlines the technology outcomes that our student teachers have been asked to achieve and reports on the preliminary results of an evaluation of the first year implementation.

The Integration Process

Several writers suggest that the integration of learning technologies be combined with an introductory course (Wetzel, 1993; Schrum, 1994; Topp, 1996). Traditionally, student teachers in our Teacher Education Program have been required to take such an introductory course. However, when pressure to drastically reduce faculty budgets were imposed, our Teacher Education Program Council decided to replace the historically problematic technology course with a cheaper and more effective model. Therefore, for the 1996-1997 academic year, the Teacher Education Program developed and implemented a project to integrate various aspects of the use of technology to facilitate learning directly into other Teacher Education courses. The purpose of the project was to design a Teacher Education curriculum in which faculty would demonstrate by example the means by which technology could be used in the Kindergarten to Grade 12 curriculum.

To achieve this, the authors took on two tasks. First, we developed a self-study module for student teachers to achieve basic technology competencies. Second, we applied an instructional development process (e.g., Seels & Glasgow, 1998; Kemp, Morrison & Ross, 1998), combined with the approach described by Todd (1993), to assist remaining faculty members to integrate technology outcomes into the B.Ed. curriculum. The intent was to select or develop the technology knowledge and competencies that we intended our student teachers to have when they graduate; to examine our existing curriculum; and to decide how best to deliver this instruction.

An innovation as extensive as the integration of technology across the curriculum necessarily engages faculty in a substantial change process. It represents a serious and personal experience for those involved and is characterized by ambivalence and uncertainty. Such a process requires time and clear mechanisms to allow participants to develop their own personal meaning (Fullan & Stiegelbauer, 1991). In order to affect program outcomes, change must also occur in practice along three dimensions: a) the possible use of new or revised materials and technologies; b) the possible use of new teaching approaches; and, c) the possible alterations of beliefs, pedagogical assumptions and theories (Fullan & Stiegelbauer, 1991). To be successful, it was clear that we had to address all three dimensions. To do so, we chose to take a diffusion/adoption perspective (Kenny, 1992) and take the stance of external change agents working directly with faculty on both a collective and individual basis. This process consisted of a needs analysis, an instructional analysis, course development, implementation and an evaluation.

Needs Analysis

To determine what technology outcomes are important for today's teachers, the authors gathered information via a literature review; contacting other programs and surveying key contacts in local school systems. From this data, we were able to generate a set of 15 learning outcomes which we judged appropriate for our program (See Table 1). These outcomes were largely derived from the NCATE/

ISTE foundations outcomes but were updated to meet more recent advances in technology and to group the outcomes into meaningful categories.

Table 1: Instructional Technology Learning Outcomes.
By the end of the Teacher Education Program, the student teacher will:

I. Attitudes:

1. develop an attitude of openness to the use of information technology to facilitate learning.
2. develop a view of the global implications of the development and integration of information technology in society and a disposition to continue life-long learning in this area.

II. Theory and Foundations:

1. explain the theoretical foundations which provide direction for the integration of information technology into the teaching / learning process.
2. apply current educational theory and research to facilitate the integration of information technology into the teaching / learning process.
3. apply information technology to facilitate the emerging roles of the learner and the educator

III. Technical Knowledge:

1. understand basic concepts and terminology related to information technology.
2. demonstrate knowledge and ability in the everyday operation of the two main computer operating systems (Windows, Mac OS) in order to comfortably utilize software.
3. demonstrate basic skills in using productivity tools, including word processing, database, spreadsheet and print/graphic utilities, to support the teaching / learning process and for administrative and personal uses.
4. demonstrate knowledge of the uses of interactive multimedia and the Information Highway to support the teaching / learning process.

IV. Integration:

1. identify resources for staying current in applications of information technology in the teaching / learning process.

2. will be able to select and evaluate information technology resources appropriate for their own subject area(s) and/or grade levels in accordance with selected learning goals, outcomes, and methods.
3. be able to integrate information technology resources in their own subject area(s) and/or grade levels in accordance with selected learning goals, outcomes, and methods.
4. be able to demonstrate uses of computers for engaging student in higher-order learning (knowledge- building. reflective thinking, problem-solving, data collection, information management, communications, presentations and decision-making).

V. Issues Pertaining to the Use of Technology to Facilitate Learning:

1. be able to demonstrate knowledge of the implications of the role of computers in society and of such issues as equity, ethics, privacy and legal implications.
2. be able to design and develop student teachers learning activities that integrate computing and technology into instruction for diverse student teachers populations.

Instructional Analysis

After selecting our technology outcomes, we next matched the outcomes with the content of existing courses with a view to where they could be best integrated. To do so, we developed a curriculum matrix similar to that of Todd (1992). This matrix was discussed, modified and ratified by our Teacher Education Program Council.

Course development

After completion of the matrix, faculty were left to work individually with the project managers to develop course activities. For the first year of implementation, faculty agreed to try to incorporate at least one learning activity in their respective courses which might meet one or more of the indicated outcomes.

Implementation

Support staff at the Faculty of Education's Learning Resource Centre (Desjardins & Kenny, 1997) and computer labs were also available to provide assistance to individual faculty. Professors could make use of up-to-date IBM and Macintosh computer labs for their learning technology activities and eight multimedia cabinets in the main centre for media viewing and development on an individual basis. They also had access to two portable computers and LCD display panels and a mobile computer station for use in classrooms.

The self study module was a requirement introduced to the student teachers during their second week of the Teacher Education Program in September. As indicated in the Course-Outcome matrix, the self study module was intended to cover only very basic computing skills (system use, elementary word processing, spreadsheet and database use, email and web searching). Student teachers were to complete the activities as needed and take a competency test. The regular computer lab assistants and a graduate teaching assistant were available each week to assist student teachers with the self study and to evaluate them.

Evaluation — Preliminary Results

Methodology

As a part of the instructional development process, we conducted an evaluation of the first year implementation of our integration efforts. The purpose of the study was to determine any changes in the attitudes of student teacherss and faculty toward using technology to support learning, to ascertain their growth in their knowledge of the use of technology to facilitate learning, and to judge how effective the integration project had been. The evaluation was conducted in two phases.

During the first phase, in September, 1996, we endeavoured to assess the initial knowledge and preparation of student teachers and faculty. Student teachers and faculty were asked to complete a demographics questionnaire, a computer attitude scale (Gressard & Loyd, 1986), and write brief answers to a set of seven questions. The demographics questionnaire invited respondents to provide information on their gender, age, and computer experience. Computer experience was assessed in this questionnaire using a computer use form originally developed by Hannaford (1991) and modified by Gabriel and MacDonald (1996). Respondents were asked to rate their knowledge and use of such computer applications as word processing, email, CAI and the World Wide Web by assigning a number from 1 - 6. Experience ranged from "unfamiliar with this application" to "use this application daily". Scores of 4 and up indicated that the respondent had actually learned and used the application.

The Computer Attitude Scale (Gressard & Loyd, 1986) consists of 40, Likert-type items assessing computer anxiety, computer liking, confidence in one's ability to use computers and computer usefulness. This scale was chosen because it has been shown to be a valid and reliable measure of computer attitudes (Gabriel and MacDonald, 1996) with Alpha coefficients ranging form 0. 82 to 091 in four studies. The seven questions were used to provide more detail on respondents' attitudes to aspects of computing in the Teacher Education Program and consisted of questions such as, "In your opinion, would learning be made easier or more difficult with computers?" and "How do you feel about the integration and self study approach to learning to use technology in teaching?"

The second phase took place in March and April, 1997. It's purpose was to re-assess the knowledge and preparation of student teachers and faculty upon completion of the 1996-97 Teacher Education Program and survey their views on the outcomes of the process. Student teachers were again asked to complete the Computer Attitude Scale (Gressard & Loyd, 1986) and to respond to a brief, written questionnaire asking similar questions to those asked during phase one of the research. For example, they were asked, "In your opinion, would learning be made easier or more difficult with computers?" and a modified version of, "At this stage in the Teacher Education Program, how do you feel about the integration and self study approach to learning to use technology in teaching?". In addition, three focus groups of approximately 8 members each (one faculty, one elementary student teachers and one secondary student teachers) were conducted to detail and expand on participants' views about our integration process. Both faculty and student teacher groups were evenly matched according to Phase One computer experience and attitude measures.

Time One Results

Computer experience and attitude ratings. Table 2 reports the mean scores on the computer attitude scale and computer experience data for both student teachers and faculty. A total of 234 student teachers completed the questionnaires at this time for a response rate of 67. 8%. Twenty faculty completed the questionnaires at Time 1 for a response rate of 35. 1%. While the mean scores are slightly higher for faculty, the range is similar for both. Further, the results indicate that both groups had, on average, experience with computing and a positive outlook toward the use of technology.

Table 2: Time 1 mean scores for student teachers and faculty overall ratings of computer experience and computer attitude

	N	Mean	Low	High
Computer Experience - Student Teachers	234	42. 1	15	78
Computer Experience - Faculty	20	53.2	33	80
Computer Attitude - Student Teachers	234	120.4	66	160
Computer Attitude - Faculty	20	130.3	68	157

Note: Maximum score for Computer Experience is 90 and 160 for the Computer Attitude Scale.

Mean ratings by application (Table 3) show that faculty report having experience with a wider range of applications than student teachers. On the average, student teachers came to the program with experience with the Windows operating system, word processing and email. They reported having little experience with applications such as desktop publishing, databases, computer-assisted instruction and simulations, all of which could be quite useful in their future instruction. Faculty, on the other hand, reported having prior experience with many of those applications.

Table 3: Mean Scores for Student Teachers and Faculty Computer Experience by Application.

Application	Student Teachers	Faculty
Macintosh Operating System	2.80	3.80*
Windows Operating System	4.60*	4.45*
Word Processing	4.98*	5.95*
Graphics	3.03	3.70*
Desktop Publishing	2.35	2.85
Spreadsheet	2.96	3.40*
Database	2.52	2.85
Email	3.91*	5.60*
World Wide Web	3.28	4.45*
Multimedia	2.30	3.35*
Authoring languages	1.31	1.70
Instructional Games	2.67	3.10*
Computer-Assisted Instruction	2.41	3.35*
Simulations	1.85	2.80
Microworlds	1.20	1.80

50% or more indicated had been trained in the application and / or used it at least once a week.

Finally, there was a strong positive correlation between experience and attitude for both student teachers and faculty. This correlation was especially pronounced for student teachers (r 0.59) and statistically significant (p 0.0001).

Student teachers questionnaire responses. The qualitative data allows a more complete understanding of the varied thinking behind student teachers' self-ratings of their technology experience and attitudes. Table 4 shows a frequency count of student teachers' answers to two of the questions on the Time 1 and Time 2 questionnaires. Student teachers, when asked about the concept of integrating technology into their own instruction (i.e., with children), were extremely positive. Essentially, they saw the use of technology as a modern day reality and something with which children needed to develop comfort. Thus, when asked if they agreed with the Ontario Ministry of Education's thrust toward integrating technology in the classroom, one student teacher stated, "I think it is good because computers are a part of our lives, so student teachers should learn how to use them, not only for games but also for basic programs such as spreadsheets, word processing". Similarly, another student teacher commented that, "Yes, as our world becomes more technological based, our school children need to be trained for what they will be using."

Student teachers were less certain about the integration approach for their own learning. From the outset (Table 4), the student teachers were quite divided on their answers to the question, "How do you feel about the integration and self study approach to learning to use technology in teaching?" At Time 1, those in favour of integration and self study tended to cite the differences in entry knowledge between student teachers and to stress the value of individual pacing. One student teacher commented, "1 like it because it gives student teachers with different levels of knowledge a chance to advance at (their) own pace."

Table 4: Student Teacher Question Answers - Time 1 and Time 2.

Question	Agree	Disagree	Ambivalent	No Opinion
Tl - Integration & Self Study in Teacher Education	34%	29%	10%	27%
T2 - Integration & Self Study in Teacher Education	27%	60%	2%	11%
T1 - Integration of Technology in Classroom	75%	7%	6%	12%
T2 - Integration of Technology in Classroom	76%	0%	19%	5%

Even those in favour, however, tended to report reservations. Another student teacher pointed out, "I feel some instruction is needed prior to use but learning can take off in so many directions (i.e., the Internet) that I feel self study is wonderful." Those who disagreed from the outset, expressed a great deal of anxiety about learning technology, cited time problems and essentially demanded a specific course on technology. A student teacher, for example, noted this about time:

> There is no instruction and you are assuming people know or have some experience of computers. Mature student teachers are particularly disadvantaged and they also tend to have an additional level of other commitment in their life. Therefore their time to learn independently is compromised. I resent it.

Another student teacher focused on a perceived need for guidance, noting that "I personally don't like it. I'm the type of person that needs a teacher to teach it to me. It's a new concept and I don't really know a lot about it."

Time Two Results

Student teacher questionnaire responses. The frequency count of student teachers' answers (Table 4) also indicates a trend, with a strong majority disagreeing with the integration and self study approach by the end of the year. While there were strong concerns among student teachers at the beginning of the year, one might expect that a good integration process would win over the majority as they succeeded in their learning. The opposite appears to have happened. These results are supported by experience and attitude ratings data, student teacher questionnaire comments and by student teacher focus group responses. The mean scores for the Computer Attitude Scale, completed at Time 1 and Time 2 (Table 5), indicate that there was little growth in student teachers' attitudes towards computing throughout the year.

Table 5: Time 1 And Time 2 Mean Scores for Student Seacher Computer Attitude Ratings.

	N	Mean	Low Score	High Score
Computer Attitude - Time 1	234	120.4	66	160
Computer Attitude - Time 2	127	123.5	81	157

Student teachers focus group themes. While the quantitative data highlights the (lack of) overall trend, the student teachers focus group interviews brought out several themes which identify their concerns. First, student teachers reported a desire for an educational technology course. They stated that the lack of an educational technology course in the Teacher Education Program was unacceptable because technology in education was extremely important. Time and money should be made available for this discipline. The student teachers suggested that they would be at a disadvantage when applying for jobs because other Teacher Education Programs have educational technology courses and the student teachers in those programs would know more about this area than they would. One student teacher pointed out:

> I just want to say that I think technology and computers and things like that are one of the most important things that we can learn right now. And I just find it strange that it's been eliminated from this particular section of the program... . Like giving this little sort of self-study little thing. And it's a little component here, a little component there. And if other schools are teaching, they are going to be way ahead. And... what are we going to say at an interview or a job at school when they say, "Well do you think you learned this?" and ... we're going to say "Well no, we were just suppose to go learn that on our own and frankly, I didn't have time.

Second, the general feeling among the student teachers was that the self-study technology module [for basic computer skills] was inadequate. Those with considerate previous knowledge and experience with technology and those with little or no technology knowledge or skill all agreed upon this point. Student teachers who had minimal computer knowledge felt they had not obtained enough knowledge and or skill to feel comfortable to use computers in their classroom. For instance, one student teacher stated:

> Because I didn't know anything about computers, that certainly what I got was too minimal. It was very minimal experience and training. And I do not feel ready to use it in the classroom at all.

Student teachers with a lot of previous experience with or knowledge about computers prior to entering the Teacher Education Program reported that they learned very little, or nothing from the computer component of the program. They went on to say that they thought there was a lot they could learn if the computer component of the program were more organized. One student teacher's comments exemplify this point of view:

> I have the computer abilities that don't necessarily, directly apply to teaching. But, I really wanted to learn more and increase my works' of teaching programs and what have you. And. I don't feel that I've learned that.

Third, student teachers repeatedly claimed that one of the biggest disappointments with the self learning module was the lack of emphasis on technology for the classroom. This was intended to be covered in courses through the integration process and indicates a wide-spread confusion between the purpose of the self study component and the integration process. Student teachers wanted more information about how to use computers as an authentic classroom tool to enhance their teaching:

> A lot of what we learned... in the self-study module was the use of applications such as Word Perfect or spread sheets, or whatever. But there was very little focus on educational... software. Or specifically how computers can be used in the classroom. It's all on learning to use the computer for yourself. It is not really focusing on education in the classroom,

A fourth theme identified during the focus group was that the computer equipment in the Learning Resource Centre was quite good and that it wasn't being well utilized. Several student teachers revealed that they did not realize that there was a scanner in the Learning Resource Centre until a student teacher mentioned it during the focus-group interview. Another mentioned that the tour of the Centre that was given to them early in the year, but it didn't mean much at that time because they were feeling overwhelmed with information. The student teachers suggested that they be shown the equipment and what can be done with it in a more meaningful way. One student teacher noted:

> The facilities that this University has, in the learning Resource Centre, I think are fairly good. Especially with the booths [multimedia cabinets], and some of the scanning equipment. However, if we had not requested a session in our seminar with that equipment, some people still don't know it exists.... You got the equipment here. Let's not just give people kind of an introductory look. Offer them workshops where they can see how you can apply these things in the classroom.

Fifth, student teachers reported that the professors did not do an adequate job of integrating computers into their program. Moreover, they implied that they didn't feel the professors had the knowledge or skill to do so. Student teachers said that there was variation in the amount of technology implemented by various professors, that professors appeared to be implementing token assignments because they had been mandated to do so, and that the majority of assignments were not useful. One secondary student teacher pointed out:

> I think there should be more implementation of computers with professors. And I know in one of classes we've had to use, make an assignment with using some form of technology with CD ROM and that was a good assignment. But, the majority of the professors haven't used computers in any of the courses that I've taken.

Another student teacher noted:

> Because the instructor was basically trying to familiarize us with how to use the internet to find resources... "Well just find the lesson plan, download it, print it. Hand that in. And if you want to modify it go ahead. I basically went up to him and I said, "Well here's my URL from my own Web page. You'll find the whole listing of various lesson plans for all kinds of things. He looks at it and checks it out and says. Don't bother. Don't even bother to do the assignment. You can leave now. So that sort of discrepancy I don't know, frustrating.

A sixth theme focused on the computer labs, which were frequently a source of frustration. Several student teachers teachers said that a factor contributing to their perception that the self-directed module didn't work was problems with the lab and not enough support in the lab. Moreover, a number of student teachers who had a lot of computer knowledge said they found it frustrating that there was not more support in the lab because they were under constant pressure to help their peers and were not able to get their own work done. One student teacher noted that:

> I think a lot of times we went to the computer room for something in class and there were too many problems.... The lab wasn't ready to have a class of thirty of us go in and try and do all the same thing, or even try to work and stuff. It wasn't working and there was so many problems and.. . the internet thing couldn't take all of us or something and there's always problems and that's what frustrates us even more.

Facultyfocus group themes. While the student teachers' views were, perhaps, more vociferous, the themes which emerged form the faculty focus group interview were quite similar to those from the student teachers groups. First, while a strong sentiment to re-establish our technology and learning course was not expressed, faculty acknowledged the problems that the differences in technology knowledge and skills among student teachers brought to the integration process. The problem, they thought, emanated from the lack of fixed dates for the completion of the self study. This comment from one faculty member exemplifies the point:

> In terms of building on the comment of pacing the independent study, I found that by January, my feeling was that some of the student teachers hadn't yet really approached the independent study package which puts them at a decided advantage in terms of when we get into the lab, our one time in there, some were far more prepared based on their own previous experience on coming into the faculty but also in the amount of time that they had spent on the independent study package. If you're going to go that approach again, perhaps having some critical, intermediate deadlines, might get people into the labs earlier to do some work on the independent study and allow them not to be at a disadvantage when they're actually in with their classes doing various assignments.

Second, like the student teachers, faculty expressed the opinion that the self study module was inadequate in scope and nature. While it had been intended only to introduce the student teachers to very basic computing skills, some professors felt it needed to be more extensive and, in fact, that this was why the integration process was less effective than it might have been. One faculty member had an especially strong view on this:

> Ah, well we've had a lot about this computer self-study module and I want to reiterate that it isn't a self-study module. It's a shopping list of things which have to be done and four pages on how to log in to a computer. That's it, there is no self-study guide. We want a self-study module, we need a self-study module for the people who are naive, but this isn't it. We don't have one. So, I mean, that in itself, is the number one impediment to successful integration. If the student teachers are faced with a full two or three pages on the stuff they've got to do, they've got to demonstrate knowledge of all this stuff and then, it's called self-study and then it tells you how to log on to the system, period. That's it.

A third theme pertained to the integration of technology into Teacher Education courses. Student teachers had strongly suggested this process was inadequate and placed the blame both on the self study module and professors (themes 3 and 5). Overall, faculty members thought that they had made an effort to integrate and cited a number of examples where and how this took place. One professor noted:

> I teach the history and personal and social studies, pedagogic course at the intermediate and senior level. There has been, I think, a fair amount of integration in that course for about the last four years, maybe five years. It's integrated through exposing student teachers to the value of ah,

> computer technology in a social science and history classroom. It is integrated through school-based models. Typically, we go to one of the local schools that integrates, especially computer technology into its history, social science program every year and see how a single department at the intermediate and senior level deals with this and it's integrated also by exposing student teachers to the latest software available in our area. They are required to work with the software by developing a lesson plan or a collection of plans that would be used in my subject area; the intermediate/ senior level. It is evaluated, it is an essential component of the course.

Faculty did, however, stress that there was room for personal improvement in the integration of computers. Several thought there was a lack of expertise in technology among faculty, as indicated by this comment from a professor:

> I would say that my awareness has grown but, and my desire to want to be able to do different things with my computer is certainly growing.... I guess I need some focus time would allow me to be able to explore in ways that would allow me to know how to use it better because. I mean, you have to be familiar and comfortable with it to be able to show it to your student teachers and to me, that is my major concern.

Faculty members also thought that there was not a strong supportive culture in the faculty for technology integration to develop. One professor pointed out when asked by the moderator if he felt that our professors were on the cutting edge of technology:

> No, all I said was that we need to be on the cutting edge, okay? I don' t think we are because we do not have the support system in place through the administration. Again, I'm not trying to attempt to put blame. I'm just stating a fact. I do not believe that we are on the cutting edge. Individuals may be on the cutting edge. But... the latest equipment in our offices does not exist to this point.... I mean we don't have the tools even to get on the main circuit.

The fourth and final theme that emerged related to perceived problems with computer resources. Like the student teachers, faculty felt that we had good resources available in the Learning Resource Centre. However, it was difficult to make good use of these resources because of a lack of access to the labs and because of problems booking out equipment. This comment from a professor sums up the feeling among professors about lab access and integration:

> The concerns that I did have, and this is not to lay blame, but, it's, it is getting time in the lab. and then when you do have a large group of people in there, we found difficulty running some of the programs because the computers were being set for different levels of memory or we had some

> difficulty overall in trying to explore the internet at the same time, the speed on the computers, etc... So, I realize that there are some things that are beyond immediate resolve, but those were some of the difficulties and dilemmas that we did come across. And, ah, I just wanted to point that out. That's one thing that I found inhibiting.

One professor had these concerns about booking equipment to use in his class outside the Learning Resource Centre that created an impediment to a more complete use of technology in instruction:

> The other thing is, availability of equipment. It would be nice to have more lap tops to, and so on and ah, some of the policies are a bit eyebrow raising about, you know, signing the things out. For example, my class started at eight o'clock in the morning. You know, if I'm having a demonstration, I want to get set up before that and I'm told I can't sign the thing out until eight o'clock in the morning. I can't take it out the night before for example. So I, you know, I have to sort of waste class time setting the thing up and there was some other bizarre policy about, you couldn't just take out the lap top, you had to take the LCD with it even if you didn't need that.

And finally, some faculty expressed a need for more stand-alone computers that could be taken to classes to ameliorate access. A professor summed this point up this way:

> I want to support this notion about the problems of taking the free-standing computer into the classroom. That, that the very evident problems that were pointed to of getting bookings in the lab, suggest to me that more stand alone units would be very useful.

Conclusions

The preliminary analysis of our integration process indicated that our first steps were halting and that several changes would be in order as we entered the second year of our project. From the student teachers' point of view, our integration process was not very successful. They strongly regretted that we did not retain our previous structure with a dedicated course on technology and learning, even though student teachers in previous years had expressed strong concerns with the deficiencies of that approach. They had problems with the quality and nature of the self study approach to learning basic computing skills and they were confused about its purpose. It did not, for instance, address the integration of technology into classroom instruction. Student teachers also expressed concerns about the efforts and abilities of faculty to carry out the integration, despite the fact that professors reported to be both more knowledgable than student teachers about computing applications and felt that they had, indeed, integrated technology into their teaching. On the face of it, the results are discouraging and highlight the strong anxieties for student teachers inherent in the use of learning technologies (Office of Technology Assessment, 1995; Gabriel & MacDonald. 1996).

It is, however, heartening to revisit the conclusions of Fullan and Stiegelbauer (1991) that an innovation as extensive as the integration of technology across the curriculum represents a substantial change process, one characterized by ambivalence and uncertainty. During such change, participants require time to develop their own personal meaning. It is fruitful, in concluding to review some of Fullan's and Stiegelbauer's (1991) "do" and "don't" assumptions basic to a successful change process in relation to our project.

First, they stress that successful implementation consists of a continual development of ideas. While we were not able to introduce a course into the mix for Year 2, our Teacher Education Council is planning the introduction of options in technology for the following year. Meanwhile, we have revised our self study module and various course teaching strategies on the basis of our dialogue with the various concerned parties.

Second, Fullan and Stiegelbauer (1991) also point out that effective implementation is a process of clarification and that conflict and disagreement are fundamental to successful change. All significant implementation efforts will experience dips in the initial stages. Given the strong criticism our process has drawn, we can perhaps cautiously take heart that our initial stumbles are a part of the normal process and continue on.

And finally, Fullan and Stiegelbauer (1991) caution change agents not to assume that the reason for a lack of implementation is outright rejection of the values embodied in the change. Rather, the reasons may relate to various factors, including inadequate resources to support implementation and insufficient time elapsed. Our project was initiated by a vote of the Teacher Education Program Council and, while some faculty continue to have their reservations about the approach, the faculty focus group data indicate that professors still support this change. More likely, as seems clear from our evaluation results, is that our implementation problems have stemmed from a combination of resource / support problems and time. Fullan and Stiegelbauer (1991) stress that effective change takes time and that it is a process of "development in use". Even specific innovations can be expected to take a minimum of two to three years. Hopefully, the completion of our second year will see us further down the path.

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An On-line Cooperative Learning Environment

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Abstract: The purpose of this paper will be to discuss a project, carried out in collaboration with two secondary schools in Palermo, with the aim of experimenting with and evaluating a cooperative learning environment based on telematic tools.
Firstly, we introduce the theoretical framework of the Virtual Classroom that we have designed; then, we present the different phases of the reported experience; specifically, we focus on the structure of the communication process which has been implemented in order to make the learning process extremely efficient. Finally, the benefits and drawbacks of the Computer Mediated Communication which have arisen during the experience are discussed.

Resume: Le but de cet article est de discuter d'un projet mene en collaboration avec deux ecoles secondaires de Palerme en Sicile (Italie), pour evaluer et experimenter un environnement d'apprentissage cooperatif base sur des outils telematiques.
Premierement, nous exposons le cadre theorique de la classe virtuelle que nous avons concue; puis nous presentons les differentes phases de notre experience. Plus particulierement. nous portons notre attention sur la structure du processus de communication qui a ete implanle de maniere a rendre le processus d'apprentissage tres efficace. Finalement. nous montrons les avantages et les difficultes de la communication par la mediation de l'ordinateur rencontres lors cette experience.

Introduction

In this context, our intention is to underline the theoretical framework of cooperative learning. According to Kaye's definition (1992), cooperative learning can be considered as the individual acquisition of knowledge, skills or attitudes as the result of interaction between the members of a group: In other words, it can be referred to as individual learning as the result of a group process.

Even though the question of whether the learning strategies based on individual approaches are more efficient than learning strategies based on cooperative approaches is unresolved (Ausubel,1990), many theoretical considerations which emphasise the importance of cooperation on learning activities exist.

Bruner (Bruner, 1984) describes the learning situation as a process which occurs inside a group, and which involves the social construction of knowledge and according to Vygotsky (Vygotsky,1978), cooperation amongst peers facilitates the development of specific skills and strategies for problem solving through the interiorization of cognitive processes which are implicit in interaction. And, communication.

By introducing telematics into cooperative learning activities, some important considerations must be made: Firstly, interaction modes between the actors in communication process are different from a face-to-face context; then, the setting where the group process takes place changes as well; and finally, it is possible to handle some aspects of this process more easily than in a traditional context [Berge and Collins, 1995]. According to the previous consideration, while on the one hand, telematics permits the implementation of extremely efficent cooperative learning environments, on the other hand, it is necessary to evaluate carefully those aspects of Computer Mediated Communication (CMC) which should be stressed and those which should be controlled in order to exploit the potentialities of telematics for didactics.

The Project

This study focused on a primary goal that is: the definition, development and evaluation of on-line cooperative learning environments using information technology for communication. In particular, we have adopted the Bulletin Board System (BBS) technology, with graphic interface, to create the on-line learning environment. Communication and file exchange occur through the tools available on BBS system: e-mail, newsgroups, shared file areas, chatting rooms.

The experience in the first year involves four classes (20 students each) of two secondary schools in Palermo (students aged between 12 and 13). The students, subdivided into groups according to sociometric criteria, are gradually encouraged to experiment with telematic communication and then with the different communication paradigms, thus creating a concrete experience of a Virtual Class. Moreover, the groups are led through different interaction schemes, as specified by the communication models, which have conveniently been designed to stimulate different cooperation strategies and to favour inter communication and communication between the groups.

During the experience the groups exchange ideas on various themes of special socio-cultural interest, concerning the different geographical areas they come from and have concentrated on the study of two Villas in these areas, which are part of the National heritage.

The Learning Environment

Defining the communication models

It is well known that, in a traditional communication setting, people can use coded as well as uncoded communication rules to establish a dialogue with other people. For example, grammatical and semantical rules can be augmented with gestures, voice intonation, stress and facial expressions. In addition, conversation is extremely flexible, since it depends on the different subjects emerging during the conversation.

In a virtual communication environment, such as a Virtual Classroom, all the communication rules must be made explicit - in a precise, but yet flexible way - before the beginning of the communication process.

Consequently, defining the communication model has been central to our work and, at the same time, very useful. A communication model is an essential tool for understanding the organization and relationships between the different stages of a planned communication process.

Firstly, it was extremely important to get models which would be both precise and flexible. Secondly, the models had to exhibit a very high degree of communicability and comprehensibility, since they had to be understood by people with different pre-skills, competencies and experiences: student and trainers. Finally, the students, but they should be able to guide all the people involved in the communication process (teachers and trainers) in the discussion of the organizational problems, didactic programming and evaluation.

In particular, both the teachers and the trainers discussed and examined the following problems:

hypothesis about the on-line learning process;

hypothesis about the modifications which occur, in the students and in the teachers, involved in the on-line communication experience;

how to improve the exchange of didactic material and ideas related to a specific subject;

the needs for tools, strategies and evaluation methods, suggestions about the scheduling of the activities, and so forth.

In conclusion, the model defining phase has produced many interesting ideas for each actor in the communication process and, as a consequence, it has been possible to reduce the difficulties during the Virtual Classroom experience.

Description of the communication process and the first results

Let's analyse the communication models defined in this experience.

The first communication model is based on the presentation of students, using a telematic identity card or "home page", created according to their fantasy. This allows each student to get to know on-line companions and enables them to understand and use telematic tools.

Once they have acquired the necessary skills, the group from each school are helped to learn and cooperate telematically using a second communication model, as follows.

The group communication process was organized according to the plan show in Fig. 1.

Remote groups are paired so that two corresponding groups gather information about the same subject: The first group of the pair deals with the general aspects of the subject, while the corresponding remote group analyses a specific case regarding the subject.

In the first stage, the bidirectional communication, between pairs of corresponding groups, takes place horizontally regarding common subjects from general aspects to specific aspects and vice versa. In this way, the material is collected gradually by the remote groups and is then integrated, discussed and elaborated cooperatively in order to carry out a thorough study of the scientific and architectonic aspects of the chosen Villas. When the group had completed its part of the research, using BBS, it is comunicated to the remote group.

Following this approach, the student understands which information he needs to request the from remote group, in order to complete his task. He can also develop learning strategies based on the collection of specific information which enables him to go from a general view to a particular one and vice versa. In this case, cooperative learning is achieved by means of certain expedients such as: the exchange of results with other groups, by means of telematic forum in order to stimulate comparison; communication, by e-mail, of the partial results of the research to the teachers. In the same way, using e-mail, teachers answer giving them adequate feedback.

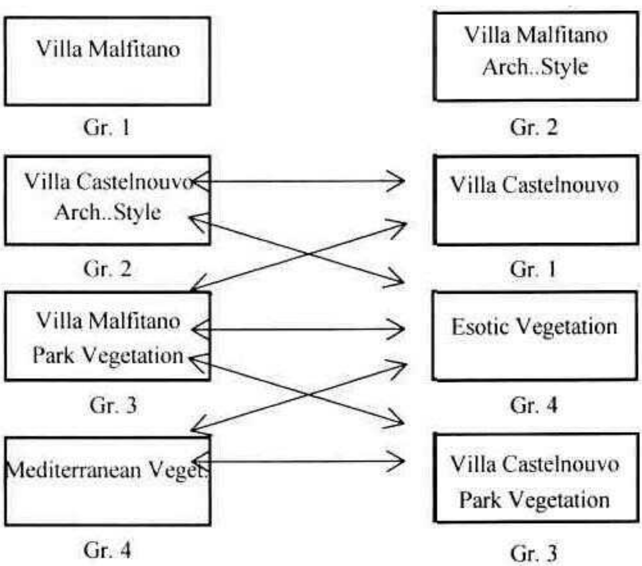

Figure1. Organization of interaction between remote groups

Beside the horizontal interaction between remote groups, as described above, during the second stage diagonal interaction was used. This helped to produce more effective cooperation between the groups which had studied the subject from a general point of view, and those which had considered specific aspects of the subject. The meta-cognitive aim of this kind of interaction is to find analogies and differences in order to integrate all the information. These interactions are indicated by the diagonal lines in Fig. 1 As hypothesized, the cooperative learning is stimulated by the comparison between the information obtained and, then, by the identification of common features of the material (i.e. an architect who designed several buildings in the different areas of the city).

Finally, using a third model, we have stimulated 'free discussions', by means of telematic forums, or of topics examined by pairs of remote groups. The purpose of this is to give all the groups an overall view of the work and so allow each student to cooperate "with and between" groups. In particular, the aim is to balance the contribution of each group and the communication flow between groups, thus allowing the students to became familiar with all the work developed. Learning is stimulated by the cooperative reconstruction of the 'concept mapping' which links the various parts of the research. Morover, in the context of this work it is necessary to underline the role of teachers and trainers. This consisted of the supervision and continuous assessment of the level of learning and participation between the individual groups, where necessary modifying the assigment of task or the communication flow between groups.

The communication in the described models, was synchronous (chatting) or asynchronous, (e-mail, file transfer, ...) as the work required.

Consideration of the experience

There were some research problems of interest to the present study:

1. the use of the computer in the interaction between the actors in the communication process allows students to improve logic cognitive skills which come from writing and reading textual documents; for example, the increase of vocabulary and the organization of the process of acquisition and transmission of knowledge;

2. because of the modification of the setting, the members join together, exchange information, establish the rules, plan the activities and organize themselves: In other words, the group cooperates in order to reach a common result;

3. in specific situations, the telematic tools simplify the management of the group processes, such as the activities of observation and feedback which are necessary to evaluate the group as a whole and the contributions of each member and in addition, telematic tools improve and encourage a self-evaluation process;

4. from a socio-affective point of view, the use of telematics aids and improves the network of relationships among peers; this is due to the fact that telematics provide new and diversified study situations for the students These situations are based on play aspects and on the cooperative value which are intrinsic in the use of the Telematics;

5. stimuli and motivation to learn are increased by the appeal typical of a new tool and of an innovative communication mode.

Besides the didactic potentialities of Telematics, some drawbacks which might arise during the Virtual Classroom experience must be taken carefully into account.

Amongst them, we report those which have arisen during our experience:

- the impact with something new and the resistance to going outside the boundaries of the own class;
- the difficulty in organising the activities of the groups in a synergetic way;
- the unfamiliarity of interacting in an indirect way;
- the difficulty of learning about the new technologies and their didactic potentialities;

As mentioned before these possible drawbacks have been carefully taken into account at the project design stages as well as during the whole experience, by performing a constant evaluation process.

Conclusions

In this paper we have discussed how cooperative learning environments based on telematics imply significant changes in the communication process among students as well as amongst their teachers, in comparison with traditional settings. Consequently, significant changes occur in the learning process.

Telematics enable teachers to guide students towards new creative learning strategies; in order to achieve this goal a key role is played by the design of the structure of the communication process and interaction.

The integration of telematics and multimedia is very effective, since it allows the transmission of complex and meaningful information - organized according to various perceptive and semantic levels - overcoming space and time constraints without breaking the interactive relationship among users.

This experience is the starting point of a wider project that seeks to enhance the potentiality of telematics as a tool to improve the sharing of experiences among different situations and participants, interdisciplinarity, the development of socio-cognitive skills and, last but not least, the recovery of school motivation in pupils with particular educational needs.

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