Videoconferencing in the Mathematics Lesson[1][2]

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Abstract

Many schools already have the facility to use videoconferencing, and, as the technology develops, this number is increasing, with schools now taking part in projects of various types in which videoconferencing is used as an educational medium. However, there has yet to be much research into the feasibility and effectiveness of videoconferencing as a medium for teaching and learning at school level in the normal classroom setting.

This paper describes a small-scale research project which was carried out to explore whether using videoconferencing in the normal mathematics lesson would help students to develop their mathematical communication skills. At the same time, technical, management and pedagogical issues which affect the practicability of using videoconferencing as a regular feature of ICT use were considered.

This study found that videoconferencing, like other forms of ICT, adds to student motivation. The analysis of the data collected supported the hypothesis that videoconferencing can help students' mathematical communication skills. It was also found that videoconferencing is possible as a part of a normal lesson, but that issues of management and pedagogy arise, some of which are different from those normally encountered.

1 Introduction

1.1 Background to the study

Although schools use of videoconferencing is increasing, with schools now taking part in projects of various types in which it is used as an educational medium, there has yet to be much research into the use of videoconferencing as a vehicle for teaching and learning at school level in the normal classroom setting, and into establishing what good practice might be (Cavanaugh 2001). A study of practice in a range of UK schools in other subject areas (funded by Becta) is currently being carried out by a team of researchers (including the present author) from the Universities of Leicester and Cambridge, in order to establish what schools are doing,

[1] This research project was funded by a bursary from Becta.
[2] This paper was presented at the BERA Conference, Edinburgh, 12-14 September 2003.

and to see if there is evidence that using videoconferencing has any effect on student attainment. This study should report early in 2004.

As far as the educational world is concerned, the literature on videoconferencing so far has tended to be focused on higher education and distance learning, with much of what has been written concerning the USA, Australia and the Far East. In their review of the literature, Heath and Holznagel (2002) found only a limited number of studies about videoconferencing with students under 19 years of age. Most of what they found concerned the use of videoconferencing to support distance learning, rather than as a tool for children undergoing a more traditional type of education. They were sceptical about findings from older students and adults being transferred without further consideration to younger students, where learning and course styles are often different.

Except in remote areas, until recently use of videoconferencing in schools has been the province of a few enthusiasts. Much of the current literature on videoconferencing use in schools is in the form of case studies on the web, although a collection of case studies from schools has now been published in Arnold, Cayley et al. (2002). Some of these case studies indicate that establishing relationships with remote participants can be difficult, but increasing the interactive element of a videoconference makes it more useful and more enjoyable for all the participants. It has further been suggested (Smyth and Fay, 1994) that successful use of videoconferencing is more likely to occur if the driving force is related to the curriculum, rather than to the use of the technology *per se*. An example of such use is the Motivate Project[3], which aims to enrich students' mathematical experience (Gage, 2001; Gage, Nickson et al., 2002).

Kinnear, McWilliams et al. (2001) studied primary student teachers who used videoconferencing as a means of observing each other teaching, and also observing class teachers with the children. Videoconferencing worked well for all concerned, with the student teachers able to observe good practice and to evaluate each other's teaching. It also provided something extra for the children in the class:

> After using the technology, the teacher of the primary school class noticed that her class seemed more motivated and enthused in their work. When the pupils were showing the students around their classroom the teacher said they perceived their video guests as important people and were more concerned with their appearance and oral communication than they normally would have been. (Kinnear, McWilliams et al., 2001).

Other accounts confirm children's desire to look good and sound good on videoconferences:

> Students perceive video guests as important and are more conscious of their appearance and oral communication. (http://www.kn.pacbell.com/wired/vidconf/intro.html)

[3] See http://www.motivate.maths.org

This website also commented on students' learning experiences:

> Students learn to ask better questions.
>
> Students show more depth in understanding.
>
> Necessary planning contributes to a better learning experience.

1.2 Rationale for this study

The research project described in this paper was designed to examine the specific contribution videoconferencing could make to mathematical communication and to explore the feasibility of its use in a normal lesson. It was felt that videoconferencing might specifically aid students' mathematical communication skills, by giving them an opportunity to discuss mathematics with another class from another school.

> Interaction is the key component of this use of the technology [videoconferencing] to support a more social learning, negotiating meaning through interaction with peers over distance, and forming a sense of community using the technology. (Amirian, http://www.iclassnotes.com/amirian_megacon.pdf)

The need for discourse in the classroom is well documented (eg. Pimm, 1987; Dekker and Elshout-Mohr, 1998). However, as Pimm makes clear, talk for the sake of it may well not be beneficial: pupil talk needs to be focused (cf. Graham, 1998). Discourse in itself is not the goal, but is the means to an end, involving the negotiation of meanings and the sharing of different points of view about mathematics (eg. Laborde, 1990; Lerman, 1996). Oral dialogue enables learners to reflect aloud on new ideas, to verbalise their insights and to resolve conflicts; it gives them space to step back, to reorganise what they have heard and seen so far, and to reflect on errors.

> Learning to direct one's own mental processes with the aid of words … is an integral part of the process of concept formation. (Vygotsky 1986: 107).

Becoming a successful learner of mathematics involves becoming fluent in the mathematical code. Without opportunities to practise the mathematical code, students are less likely to become fluent in it, and hence to move on to become successful learners:

> School introduces children to aspects of the mathematical and scientific register (eg. vocabulary items) but provides them with relatively few opportunities to practice these registers. (Forman and McPhail, 1993:226, cited in Daniels, 2001:127)

This comment, although made in 1993, still rings true ten years later, despite considerable emphasis on the value of mathematical discussion in the classroom. Yet genuine dialogue in the classroom is not common: discussion is orchestrated by the teacher, with students often only giving very short answers. When students are asked to explain their thoughts, they frequently find it immensely difficult to do so, lacking the mathematical vocabulary, the ability to structure their thoughts clearly, and the confidence. It is here that videoconferencing has something very valuable to offer the teacher, providing, as it does, opportunities for students to practise explanations, and to gain confidence in talking about what they think. Where there is no shared history from previous lessons, students need to be much clearer in what they say than is sometimes the case in classroom discussion, necessitating their thinking through their subject clearly in advance. This requires students to develop an appropriate vocabulary and clear reasoning, thus improving their communication skills.

It takes practice to be comfortable with videoconferencing and to use it successfully for genuine interaction, so overnight miracles were not expected. The two schools involved in this project were only able to meet four times during the study via videoconference for about 30 minutes at a time, so it seemed unlikely that there would be much of an effect on the students' communication skills. However, it was hoped that this would be enough to judge whether using videoconferencing in this way was possible, whether it was useful, and if its potential for enhancing communication was worth investigating further. To do this, student and teacher attitudes were explored together with pedagogical issues which arose. Technical problems were also investigated to see if there were problems here which would mean that however useful videoconferencing might seem, it would be too difficult to use in normal classroom teaching.

2 Methodology

Four Year 8 classes of comparable ability were chosen to take part in this study from two different schools. One class at each school was an experimental group which took part in the videoconferences, the other class at each school was a control group which did not take part in the videoconferences. As this was a small-scale case study, it was felt that a qualitative methodology would be most appropriate (eg. Creswell, 2003). All data collected were of a qualitative nature, consisting of semi-structured interviews, questionnaires containing open-ended questions, videotapes of classroom discussion and accompanying written work. The interviews and questionnaires were analysed to find out about the teachers' and students' views on videoconferencing, including any problems encountered, and their views for its future potential. The transcripts of the classroom discussions and the students' written work were analysed to see if there were any changes in the students' mathematical communication skills after the videoconferences. Similar data were collected from the control groups for comparison. It cannot be claimed that the videoconferences were the sole possible cause of any changes, of course, but it was hoped that an indication could be gained as to whether further research in this area would be worthwhile.

2.1 The schools

The two schools which took part in this research project were both in medium-sized towns on the south coast of England. School A was a co-educational comprehensive school with about 1000 pupils on roll in 2002, of whom 22% were on the SEN register. 63% of students in 2002 achieved Level 5 in Mathematics in the end of Key Stage 3 tests. School B was a girls' comprehensive school, which had around 940 pupils on roll in 2002, of whom 8% were on the SEN register. 74% of students in 2002 achieved Level 5 in Mathematics in the end of Key Stage 3 tests.

2.2 The students

The age of entry to school A was 11, and so the two classes involved in this study had been at the school just over a year when this project started, most of them in the same maths class and with the same teacher throughout that period. The teacher (teacher A) of the experimental class (class A) assessed both classes as of middle ability, expecting them to gain B or C grades at Intermediate level at GCSE. She characterised class A as "a very keen group" although "not the quietest group", with around half of them having "a lot of enthusiasm for the subject". There were only 19 students in the group, and as they were borrowing videoconferencing equipment, which could be put up in a normal classroom, the whole class took part in the videoconferences.

School B's entrance age was 12, so their Year 8 students were new to the school and to the teacher (teacher B) less than a month before this study began. Teacher B commented in his interview that the girls were still getting to know each other and him, and that he thought this perhaps made them less confident than they might otherwise have been. This school also had a major review of their maths sets during the term, so the groups changed shortly before the final videoconference. The experimental class (class B) was below middle ability according to the teacher, whereas the control group was a little above, but he expected both groups to do the Intermediate paper at GCSE, and to gain C or B grades. Characterising class B, teacher B said they were motivated to do well at maths, although for some this was because it was a necessary qualification rather than because they found it intrinsically interesting. This school had its own videoconferencing equipment in a dedicated studio which could hold about 12 people, so the whole class did not take part. Those who did take part in the videoconferences were all volunteers.

2.3 The teachers

Teacher A was in her second year of teaching, having started her teaching career at school A the previous year. Her involvement in this project was largely for pragmatic reasons, as she was not the original contact at this school. She had been involved with the videoconferencing that had taken place during the previous term, and she taught an appropriate class at times which coincided well enough with the

times of the maths lessons of class B. Teacher B was the Head of Maths at school B, and had been teaching for well over twenty years. He was supported during the lessons[4] in which the videoconferences occurred by another teacher, who was the previous Head of Maths, and had also been teaching for well over twenty years. Teacher B's involvement stemmed from his desire to "find … aspects of mathematics that motivate pupils" and to "give maths a slightly higher profile". He was also keen "to communicate with other schools", and to "learn and widen [his] practice". The support teacher wanted to "broaden [her own] experience and involvement with ICT". As a Department they said they were "committed to ICT", wanting "to be at the leading edge".

3 The videoconferences

The two schools agreed to hold five videoconferences of about 30 minutes each at fortnightly intervals, starting at the end of September 2002. One of the maths lessons of the two experimental classes coincided more or less, although it meant the school B students losing 15 minutes from their lunch break and having an extended double period of maths. In fact, only four videoconferences were held, as school B had a training day[5] on one of the arranged dates, and it was not possible to find another time when the videoconference could be held. Initially, it was thought that 30 minutes would be quite long enough for people who were not used to videoconferences, but teacher B commented: "generally they were too short". Getting "the hiccups out the way" took five minutes, doing introductions and giving as many students as possible the chance to feed back on a question took time, with the result that "sometimes we only had them actually working for fifteen minutes", although he agreed that they were practising their communication skills throughout. He felt that the videoconferences were rushed, and that more time would have been an advantage.

None of the teachers said they did much preparation for the videoconferences with their students. Teacher A explained to her students beforehand what videoconferencing is, and how it works. Once the videoconferences were underway, she discussed technical and pedagogical issues that arose with the students. Technical issues were to do with the picture and sound quality, and what implications these had for what the students did in the next videoconference. Pedagogical issues concerned how to get ideas across to the other class, such as by direct explanation, or by using PowerPoint slides. Teacher B merely asked who would like to take part, and explained how to talk into the microphone. He and his students also had informal discussions between videoconferences about how things had gone, what had worked and what had not, and how they might do things better.

Topics for the videoconferences were agreed by the teachers at the planning meeting at the beginning of the project, but were changed as necessary during the term (by telephone and/or e-mail) according to the schemes of work followed in the two

[4] This support was necessary, since not all the class could take part in the videoconferences, and so one teacher needed to go with those taking part, and the other needed to remain with those not taking part.
[5] When students were not in school.

schools and the students' progress. The first conference was mainly social, giving the students a chance to introduce themselves to each other and find out about the other school. Then each class set the other a short problem which they could work on for the next videoconference.

Teacher A found that organising the videoconferences conflicted with completing topics: “I didn’t think I was doing things properly, I was missing things out in my lessons”. Teacher B wondered if it might have been better to have a theme just for the videoconferences, rather than trying to keep step with two different schemes of work, but felt that this would need to be tried first before a judgement could be made. Neither teacher found preparing suitable materials a problem however, taking it in turns to choose an activity, with the final one prepared jointly. Both teachers felt that the open-ended tasks they chose were the right kind of thing for the videoconferences, making it easy for students of different abilities and backgrounds to access them.

4 Results

4.1 Interaction and communication

After the final videoconference, students were given questionnaires to complete. In answer to a question asking what was good about videoconferencing, one student responded: “We get to interact with children in a distant school”. Another wrote: “You got to meet other people and hear their method of working out, and working out their problems”. Many other comments were made on the questionnaires referring to students interest in finding out about the other group of students, and seeing how they worked. Some students were amazed that it was possible for them to share a lesson with another class forty miles away. Interaction was clearly viewed as an important feature of the videoconferences, and was felt to be motivating by the students.

Communication was, however, felt to be more difficult. In interviews with small groups of the students, it was possible to discover in more detail how they felt the communication between the two classes had worked out. Some of the students said that they felt shy about talking about maths during the videoconference, because they were worried about making fools of themselves, and also because they found it hard to judge whether the other students had understood what they said. Having to explain their answers was also more difficult than just answering a question:

> So it’s not easy to do, like trying to understand, and trying to do the maths, and be able to explain stuff, rather than just answer it. Like, two add two equals four, you had to add two add two is four *because* …

Students and teachers also referred to the difficulty in communicating with people you could not always see or hear very well, and having to accustom yourself to the delay

in the sound[6]. Overall, however, all the teachers and the vast majority of the students thought the experience useful for the students' communication skills:

> They did start to think about how to say what they needed to say … so they were thinking about the communication of the ideas. … There was a discussion going on between themselves about the best way to say it. *[teacher B*]

> It was good because I think it forced children to really think about what they were saying … it puts them under quite a bit of pressure when there's a mic there. *[teacher A]*

Analysis of communication skills

Students' communication skills before and after the videoconferences were explored using video-ed classroom discussions both with the students who took part in the videoconferences, and in similar control groups. Written work from the investigations used in these discussions was also analysed. Standard investigations used with Year 8 students, which neither school had used with these students before, were used for this. In each case students worked on the investigations for an hour or two before the discussions were held.

Transcripts of the students' contributions to class discussions, and their written work, were analysed by phrase/clause /statement for clear/correct and unclear/incorrect phrases. Only mathematical statements were considered, with remarks like "Shall I talk now?", and "I've stopped laughing", ignored. Clear/correct statements (CS) were not analysed further, but unclear/incorrect statements were broken down into five further sub-categories. These were 'insufficient information' (II), 'imprecise use of language' (IL), 'incorrect statement' (IS), 'meaningless statement' (MS), and 'stuck, needed prompting' (SP)[7]. Clearly context is important, and statements cannot be categorised without taking into account the rest of what a student said or wrote. Written work was also often exemplified with diagrams and/or calculations. However, a flavour of these categories can be gained from examples:

CS: …this diagonal line covers 4 squares on a 3×2 rectangle …

II: … if you divide the last number by the length of your square … *[it was not clear what 'the last number' meant]*

IL: … if you times 3 and 11 and take away from 1 and 9 … *[meaning $1 \times 9 - 3 \times 11$]*

[6] The impact of sound and picture quality on communication and pedagogy is considered further in 4.3 Problems experienced.
[7] This was not relevant to the analysis of the written work.

IS: It's a 4×4 square inside a 3×3 grid … *[How can you have a 4 ´ 4 square of numbers in a 3 ´ 3 grid of numbers?]*

MS: …for example … nine in length, three in width equals nine so ... that the common factor is separate …

SP: I can't explain it though … is there a connection between … the …

Changes in students' communication skills

Less than 30 students were involved in each of the oral discussions, and written work was obtained from a small sample of each group from school B only, so any conclusions need to be treated with care. The videoconferences were also not the only factors which might have impacted on the students' mathematical communication skills during the period concerned. However, there is sufficient evidence to indicate that it would be worthwhile investigating further the degree to which videoconferencing can assist students' mathematical communication skills, both oral and written.

Figure 1 shows the relationship between the proportion of clear/correct statements and unclear/incorrect statements for the oral discussions for each participating class. The experimental (videoconferencing) groups at both schools increased the proportion of their clear/correct statements relative to their unclear/incorrect statements after the videoconferences, whereas the control groups did not. As already stated, this may be due to factors other than the videoconferences, but it does indicate that this is worth further research. Figure 2 shows that this was also the case for the written work from school B. (Teacher A did not feel that the school A students had produced any written work worth submitting for analysis).

Figure 1: A comparison by school and class of the proportion of clear/correct and unclear/incorrect phrases used by students as a percentage of the total number of phrases analysed from the class discussions

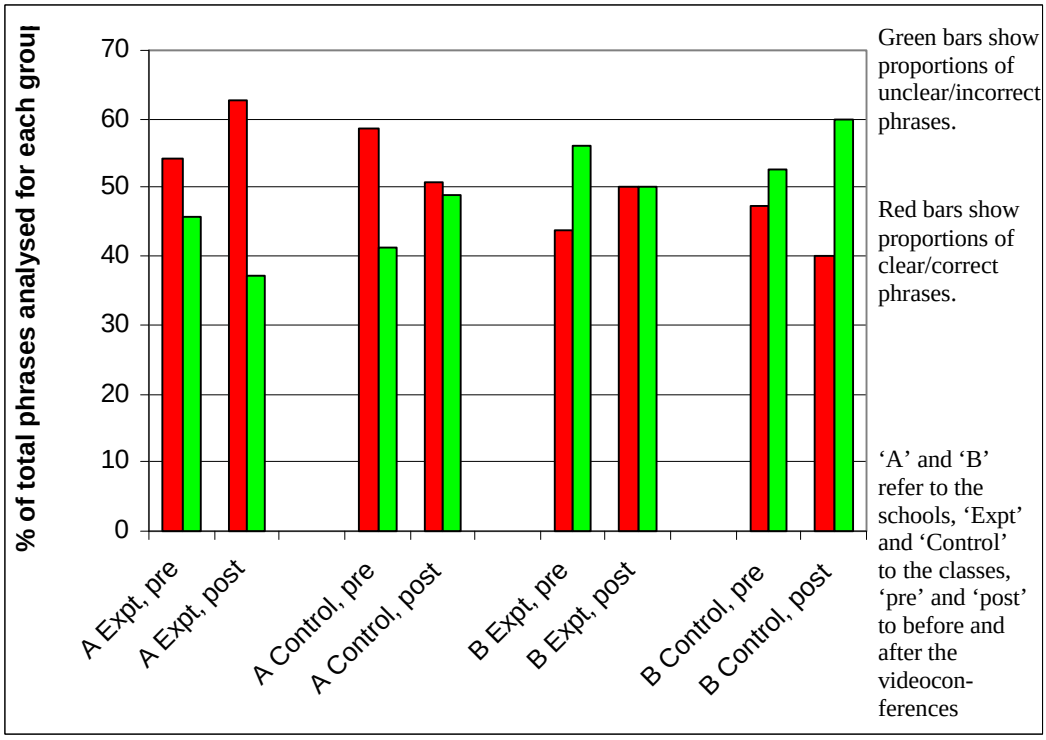
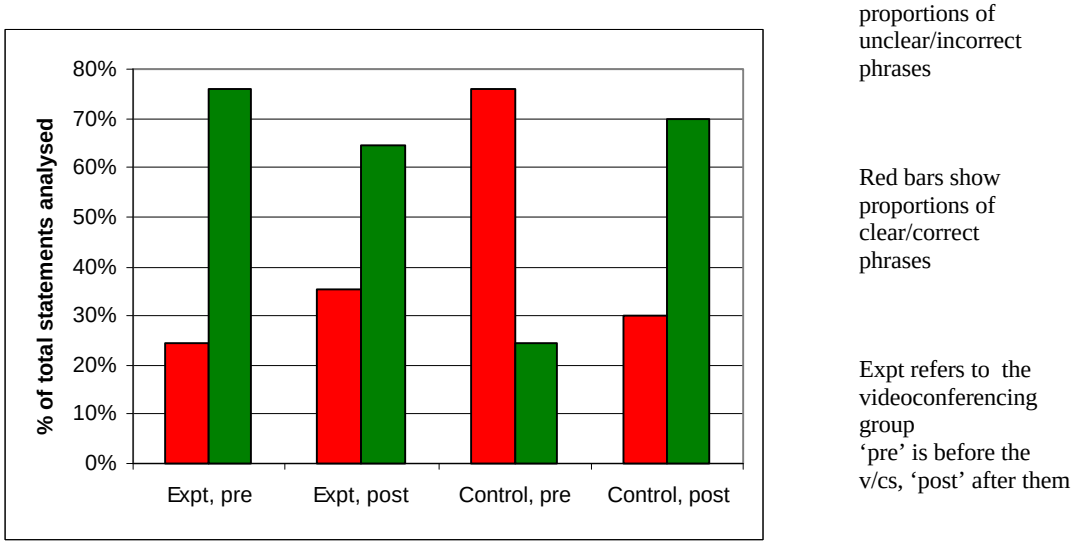


Figure 2: Comparison of clear/correct phrases and unclear/incorrect phrases in the written work of school B



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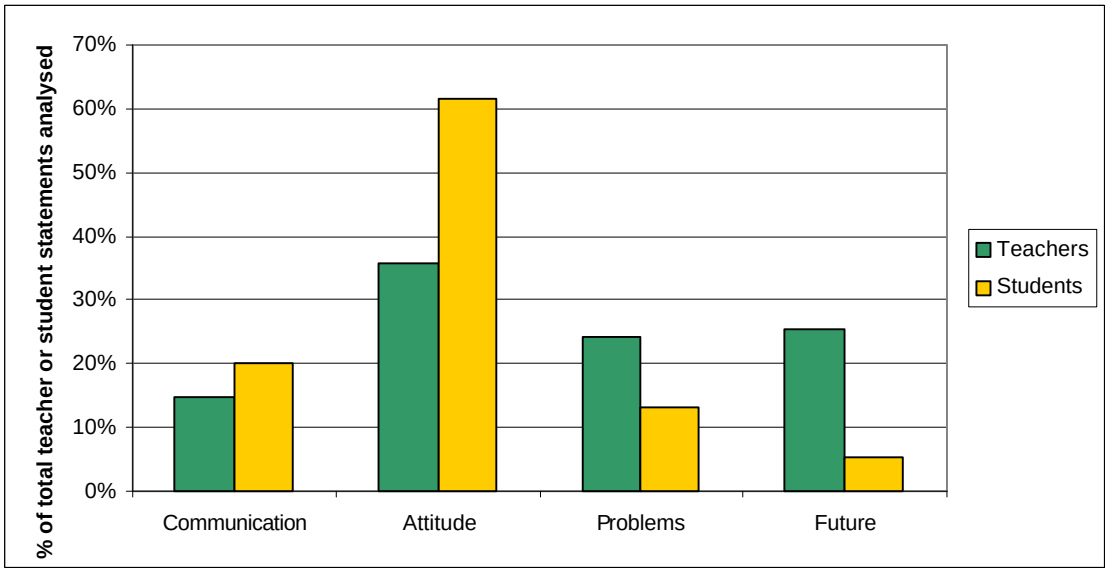
Teacher B put a note in with the written work, saying that the experimental group were “below average ability” and that the control group were “above average ability”, which shows up very well in the coding for the first task (pre-videoconferences). As with the oral discussions, the control group (the higher ability group) started with a better proportion of clear/correct statements, but the videoconference group performed better after the videoconferences.

4.2 Attitudes to videoconferencing

Views on the videoconferences were analysed using data from teacher interviews and from student questionnaires and interviews, by sorting statements into four broad categories which emerged from the data: ‘interaction and communication’, ‘attitude to videoconferencing’, ‘problems’, and ‘future potential’. A total of 266 teacher statements made by the three teachers were analysed, and 373 student statements from the 31 students who had taken part in the videoconferences. Figure 3 shows the proportion of student and teacher statements analysed which related to the major categories identified from the interview and questionnaire data. It can be seen that both students and teachers had most to say about their attitudes to the videoconferences, with students saying more about these than about anything else. Teachers were more worried about problems than students, and had more to say about the future potential for videoconferencing in the classroom, while students had more to say about communication and interaction.

Figure 3: Distribution of students’ and teachers’ views on videoconferencing



Both teacher and student comments were largely positive, although a few students from school A (who were not all volunteers) had not enjoyed the experience, and

some from class B were not happy at losing a little of their free time (despite being volunteers). The interviews and questionnaires all included specific questions about what was good about the videoconferences, and what was bad. Good things about the videoconferences that were commented on included:

> I think it was valuable in terms of helping their positive attitude towards the subject. I think it was valuable in terms of motivation. *[teacher B]*

> … you can get to teach them as well, like you get to have a say in what you learn … *[student, class A]*

> I found it interesting and fun to talk to other schools about the subject that you find hard or to share your answers. *[student, class B]*

Bad things about the videoconferences that were commented on included:

> Where I don't think it was valuable, or good value, was in the time it took and the maths we got out. *[teacher B]*

> Not good was probably the picture and sound. *[student, class A]*

> … we didn't get to know the people at the other end. *[student, class A]*

> I didn't like it being just all about maths and nothing else. *[student, class B]*

Confidence and the lack of it were also commented on:

> But those who were normally brave enough to talk in class talked on the microphone. *[teacher A]*

> … because they were confident and keen, keener by the end, they were able to communicate better maths. *[teacher B]*

> … it did get that much tiny weenie bit easier, so yeah the more I did it the easier it got. *[student, class A]*

> … the first time it's really embarrassing … *[student, class B]*

One student from class B made the interesting observation that it was easy to talk to the other students over the videoconference because "you weren't, like, totally there with them, so it was all right".

The support teacher at school B had clearly found it an ordeal, whereas the other two teachers did not:

> I was quite happy being in there … *[teacher A]*

> I can't get through the fact that I felt very uncomfortable with it. … I find the camera quite inhibiting. *[support teacher, school B]*

Summarising, attitudes to videoconferencing were largely positive, with both students and teachers making frequent comments about gains which would not have been present in a normal lesson:

> I think it's given a different focus to mathematics and I think it made them feel quite special … [It] gave them an exposure to other people, broaden[ed] their horizons … *[teacher A]*

> I found it hard because I get stage fright and I can't talk to people, so talking to loads of other people with a microphone in front of all my class, I found hard. … But I'm proud that I actually managed to do it. *[student, class A]*

> We learnt new things, and met new people and were able to communicate with people we didn't even know. *[student, school B]*

4.3 Problems experienced

Both teachers felt there were technical, management and pedagogical issues which were quite different from the normal classroom situation. Matching timetables at two different schools operating A and B week timetables was difficult. Teacher A felt that with a smaller group (her group was normally 19 students) it would have been easier to involve them all both in preparation and during the videoconferences. Teacher B felt that the videoconferences were not long enough to allow both groups to contribute fully, particularly given the need for students to spend time getting to know each other. He also felt that ideas had to be tried out before it was really possible to know which activities worked in a videoconference, and which did not.

Technical issues produced what teacher B referred to as the "learning curve":

> … and it's a bit of a learning curve, about what to say and what not to say and when to say it. And it was difficult, because when you make contact on the videolink, actually many times you can't see them[8]. The camera zooms to them after you've started speaking … I can't see you and then

[8] On a TV screen, it can be difficult to see individual faces in group shots.

> start speaking. I have to speak and then see you, and that's a rather different way round to what we're used to.

Sound and picture quality had management and pedagogical consequences. Sound was a problem for school B, who only had one table/floor microphone, compared with the radio-microphone school A was using. Teacher B commented that Year 8 girls often have soft voices, and that many of them found it difficult to make themselves heard. However they managed this problem for themselves:

> … I thought the girls handled the communication very well. They very quickly realised who wasn't being heard and so they tried to overcome that …

Students from both schools commented on sound and picture issues: "You couldn't hear them very well and the picture was all fuzzy[9]." It is clear that if videoconferencing is to be used on a regular basis, sound and picture quality need to be considered, and participants need to be trained to make the most of the available technology. Teacher B commented several times that if he were to do something like this again, he would spend much more time training the students in advance. However, teacher B also noticed that the need for the class B students to work around a single microphone led to a much more collaborative approach than normal, which he saw as an unexpected bonus.

4.4 Future potential of videoconferencing

The majority of the students (about 80%) and all the teachers felt that they would like to be involved in videoconferencing again, despite the difficulties they had experienced. In the future, teacher A wanted students to be able to take a greater part in planning and carrying out the videoconferences. She felt this would be easier with a smaller group, say about 12 students, as in class B. She also recommended the use of a radio-microphone, because apart from being able to hear people better, this gives an indication of who is speaking, which it can be difficult to see. Another point she made was that it would facilitate communication between the two sites if the students had a chance to meet physically at some point. She did not feel increased workload was a particular issue: "… it wasn't an awful lot of extra effort, to be honest".

Teacher B wanted the videoconferences to be longer, feeling that half an hour did not give time to go through social introductions, and then really get into some mathematics. He also mentioned the need for a radio-microphone, so that students with quiet voices would also feel they could contribute. He thought it would be useful to build in time outside the videoconference to produce tangible results, such as display materials, for which the videoconference would be the catalyst or stimulus, so that the students would be able to say "This is what I did in the videoconference, let me show you."

[9] Movement causes the picture to break up temporarily.

5 Summary and Conclusions

This study indicates that videoconferencing has the potential to enhance students' mathematical communication skills. The students who took part in the videoconferences in this study, despite only being involved in four half hour videoconferences, showed an increased level of clear/correct phrases in both their oral and written work. Using videoconferencing in normal lessons was found to require new thinking about content and management but proved possible without increasing teacher workload unacceptably. Videoconferencing also appeared to offer occasions for genuine collaboration between students, both within a school and across schools, and to be motivating for both students and teachers. However, technical factors were found to impinge on the learning experience, and would need careful consideration so that inadequacies in equipment are minimised, including training of students in the use of microphones.

Further research is required to see if the findings hold over a wider variety of schools and in other subject areas however. The current Becta funded research project conducted by the Universities of Leicester and Cambridge should give an indication of current practice, and whether it is yet possible to see any connection between videoconference use and student attainment. More detailed research into issues such as communication skills, student confidence and the opportunities for collaborative learning also need to be conducted.

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