Teaching and learning in telematics classrooms: Fostering higher level thinking outcomes

In Western Australia telematics (audiographic teleconferencing) is used to deliver curriculum subjects to students in remote and rural locations. Communication between students and teachers is achieved by combining telephone, facsimile and computer links, and by providing different levels of teacher-student interaction. Teaching via telematics overcomes many of the problems of remote and distant learners as lessons are transmitted from the metropolitan area to a number of rural sites simultaneously.

Previous research on telematics classrooms (Oliver and Reeves, 1994) indicates limitations on teaching strategies adopted, in particular the didactic teaching style that teachers demonstrate when teaching via audiographics.

In 1996 an initiative by the Education Department of Western Australia extended the use of telematics for delivery of educational programs to gifted and talented students in rural and remote areas. The aim of the project was to apply innovative approaches to teaching via audiographics, and to foster higher order learning in students by linking them with other students participating in the academic talent program.

The paper will discuss both constraints imposed by the technology and how teacher pedagogies may be adopted to maximise the communicative processes in telematics classrooms in order to foster higher order thinking skills in gifted and talented students.

Telematics in WA

In Western Australia and Victoria, a considerable number of schools use audiographic technology to teach classes in rural and isolated areas. According to the Victorian Ministry of Education and Training Report (Conboy, 1991), the term telematics is described as: electronically based equipment and the processes and strategies used to enable interactive teaching and learning between two or more geographically remote locations. In audiographics teaching there is a physical and geographic separation of students and teacher, with a teacher sometimes delivering the lesson to one or more sites.

Three forms of technology enable the interactive link to be set up and maintained. The telephone provides interactive voice contact and a two way communications link. A computer is used to share visuals and graphics. The screen can provide a number of interactive supports for learning:

- immediate feedback to students when used as a blackboard;
- visual stimulation;
- a flexible, editable page;
- shared reading and writing; and
- a record of written work that can be saved and printed.

As telematics lessons also use print based material, a facsimile machine may be used to transfer documents and teaching materials, thereby enhancing the immediacy of the teaching experience for learners. A typical lesson could involve a teacher in one location with her/his own class and simultaneously teaching groups of students at other sites. Close collaboration between sites is therefore required, and the success of each teaching session is largely dependent upon the ease and transparency of the technology.

Telematics environments (audiographics) depend for their success on the maintenance of a two way audio communication via the telephone. Without the audio link, it would not be possible for the lesson to proceed as it is the medium through which classroom management and rapport is established. While computers at two or more sites are linked, giving teachers and students a view of the same information on the computer screen, the teacher uses the audio link to manage the lesson. The development of effective listening and speaking skills is therefore fundamental to both teachers and students participating in telematics classrooms. There are many advantages of voice contact to learning and thinking critically, and research on
higher level cognition (Mercer, 1994) affirms the importance of using student talk to:

- share ideas and concepts;
- expose multiple ideas and viewpoints;
- develop skills of argumentation;
- discuss and experiment with ideas;
- cultivate a sense of audience awareness.

Dialogue is therefore critical to telematics environments and it is through verbal interactions with a teacher and peers that students participate in learning at a distance.

The potential of telematics to deliver interactive and efficient instruction to remote sites is documented in the literature (Oliver & Reeves, 1994; Rehn, 1994; Stacey 1993; Oliver & McLoughlin 1997).

**Educational applications of telematics**

The rationale for the use of telematics in Western Australia has ranged from equity issues to curriculum provision and extension programs for academically talented students. This is demonstrated by employing telematics for various educational ends.

(i) Extending the range of curriculum subjects offered throughout rural areas. Clusters of schools have organised themselves to share resources and teachers so that all participating schools have access to a broader range of subjects. This was subsequently known as the Priority Country Area Program or PCAP (Oliver & Reeves, 1994).

(ii) Enabling schools in rural areas (on the basis of equity and access) to receive specialist programs, such as languages. Japanese, Italian and French are currently offered.

(iii) Providing schools in rural areas with the opportunity to have a specialised curriculum, for example gifted students in rural areas should have access to the same range of programs as schools in the metropolitan area. By linking schools in metropolitan and country areas, talented and gifted students are expected to benefit from collaborative activities and exchange of views with other students in the program.

In 1996 the Academic Talent program was offered for the first time via telematics. Four schools in the Perth metropolitan area were involved in delivery of mathematics, science, humanities and LOTE to a cluster of five rural schools. Most lessons were multipoint deliveries, ie teachers taught to two or more remote schools simultaneously.

**The academic talent program**

The Curriculum Frameworks (1995) for the Academic Talent Program (ATP) were developed to encourage and support the development of students’ cognitive, social and emotional well being regardless of location, gender or social class. The curriculum frameworks are couched in terms of outcomes, or performance with demonstrated ability. Outcomes based education has the following characteristics (Willis & Kissane, 1994):

- An outcome is a demonstration of learning that occurs as a result of a learning experience.
- Curricula are designed to achieve specified outcomes.
- Courses are evaluated in terms of their capacity to help students attain stated objectives.

The academic talent program, in addition to espousing outcome statements, also seeks to develop an integrated curriculum by extending relationships between the disciplines.

The particular higher-order learning outcomes for gifted students, as stated in the Curriculum Framework (1996) documents include generic thinking skills and handling of information. These include:

- independent learning strategies;
- information handling and synthesis;
- independent learning;
- reflection and analysis to generate and refine knowledge;
- question generation and analysis;
- presentation of arguments;
- effective communication; and
- participation in group work.

Teachers utilise the curriculum guidelines to develop programs which extend, enrich and accelerate talented students in a special program tailored to their needs. The provision of such a program via telematics presents interesting challenges insofar as it entails exploiting the technology to achieve a level of communication that will extend learners’ thinking skills.

**Distinctive features of telematics environments**

As the teacher and students are physically separated and communications are mediated electronically, there is a need to understand the form, nature and effectiveness of technology and pedagogy in telematics environments in order to evaluate their educational impact (Collis, 1993; Catchpole, 1993). These considerations are essential to planning educational experiences for gifted students in telematics environments intended to support higher level thinking skills.

In contexts where communication is mediated through technology there has been much debate on how learning takes place, and how communication and interactivity are established and supported (Salomon, 1981). Research from various disciplines has recognised the importance of dialogue and interaction to education, and the need to establish communication between the parties involved (Fulford and Zhang, 1993; Bruner, 1984).

However, learning at a distance differs in important ways from learning in face-to-face, teacher fronted classrooms.

The physical absence of a teacher and the use of communications technologies to support interaction are the most basic differences. The loss of visual contact between teachers and students is a significant feature of learning via telematics, and one that has been found to determine particular styles of teaching. Where there are few non-verbal features and contextual channels to support communication, the dependence on oral discourse is increased (Thompson, 1996). Where talk is taken as a sign of connectedness, silence may be regarded as lack of rapport, and studies of telematics classrooms have found that a great deal of teacher talk fills telematics classes (Oliver and McLoughlin, 1997), sometimes perhaps to the detriment of student initiative and opportunities to question.
Writers reviewing the instructional strategies employed by users of teleconferencing technologies have raised the question of whether the attributes of effective face-to-face teaching are the same as those that constitute effective teleteaching (e.g., Gehlauf, Shatz & Frye, 1991). Often, technologies are used to present one way lectures to students and the interactive features of the technology are not fully utilised (Jonassen, Davidson, Collins and Campbell, 1995). Instruction with teleteaching often reveals the use of only a narrow range of instructional strategies based primarily on conventional teaching practices (e.g., Gehlauf et al., 1991; Oliver & Reeves, 1994).

There is an acceptance among many researchers that there are new skills that must be developed for effective teleteaching. Some have describe these as “immediacy” behaviours, a term closely associated with telepresence, or the ability to achieve a rapport with remote students. Many of the guides to telematics teaching stress the need for a facilitating role for the teacher (Elliott, 1991; Conboy, 1992) and a consequent reliance on student responsibility, resource based approaches and the expectation that students will be able to learn in an independent mode. It has also been observed that students learning at a distance must take more responsibility for their own learning as the physical absence of the teacher means that students have to take the initiative to ensure that equipment is functioning, provide feedback to the teacher on how the lesson is being received, and be self reliant in completing tasks.

Because of these cognitive and social demands it would seem that telematics classrooms are ideal environments for higher level thinking skills. Furthermore, since communication and dialogue are fundamental to communication via telematics and classes are usually small (up to twelve participants), students are advantaged in terms of student-teacher ratio and the potential opportunities for increased dialogue. However, a number of constraints have been identified that are likely to impede academic achievement unless addressed by appropriate action and teacher pedagogies.

**Constraints on teacher pedagogies**

There are constraints that operate in telematics classrooms because of the lack of non-verbal features to support dialogue. Students may misunderstand, or be apprehensive about using the technology, and fail to participate to the maximum level. Although students are usually given an orientation to telematics they still have to cope with technical breakdowns, new communication protocols for audio-based interaction and the development of new social skills (Gunawardena, 1992). For teachers, features of telematics classrooms that require planning and effort are:

- advance planning and preparation of computer screens;
- use of technology to mediate communication;
- simultaneous technological links to geographically separated classrooms; and
- reliance on computer technology to provide a shared visual reference.

In telematics classrooms, unlike face-to-face classrooms, the teacher must be sensitive to the problems students may experience with communication and technology, plan activities in the event of a computer breakdown and employ pedagogic practices to enable all students to participate. These additional demands also mean that teachers have to be technology competent and aware of the impact of the technology on teaching style and the social climate of the classroom.

Research into the effectiveness of audographics as a medium for delivery of educational programs has yielded considerable insight into the pedagogic practices of teachers, their attitudes towards implementing the technology and the constraints it imposes (Stacey, 1993; 1994; Anderson & Garrison, 1995). In distance education, communication between the teacher and the learners is still the critical feature of the learning process, though it is mediated electronically in telematics. Pervasive in the literature is the belief that telematics is second best, a poor-alternative to face-to-face teaching. Not surprisingly, such a negative attitude would be likely to affect teachers’ perceptions of the effectiveness of the technology.

For teachers, some of the difficulties documented included:

- conducting an effective lesson without eye contact;
- trying to get to know students without seeing them;
- lack of feedback from students;
- feeling of pressure and stress in trying to involve all students actively; and
- lack of instant visual and graphical communication.

One of the contradictions that emerges from the research on telematics teaching is that while teachers depend on highly motivated, co-operative students for the success of the lessons, they rarely make their lessons fully learner-centred, and persist in retaining control over the pace and sequence of interactions at all stages. The inherent contradiction between the desire to achieve a motivating, interactive learner-centred environment and the effort made by
teachers to maintain control over all aspects of teleteaching is another striking feature of research on telematics classrooms (McLoughlin & Oliver, 1995).

Other studies (Oliver & Reeves 1994; Evans & Nation, 1992) indicate that limitations on interactions often result from the technology, the teacher’s management strategies, or a combination of both. Didactic forms of teaching are observed to be prevalent. Evans & Nation (1992) reported that their observations confirmed that teachers felt compelled to use the audio link to compensate for lack of visual cues and this resulted in the lessons being didactic and interrogative. The adoption of a teacher-centred approach was evident in teachers’ persistent questioning of students. The observations made by Evans & Nation (1992) lead them to conclude that the main agenda for teachers was to maintain control and discipline in their classrooms, and the use to which the technologies were put appeared to support this approach.

These findings are confirmed by Oliver & Reeves (1994) who reported that teachers exerted control over the dialogue through:

- leading questions that required no answers;
- questions that were answered by the teachers after short delays;
- questions that could not be answered;
- setting task for students; and
- directives to individual students.

It was also observed that there was an inverse relationship between teacher dialogue and student verbalisation throughout the lesson: as student responses diminished, teacher talk increased, resulting in a decrease in interactivity.

In reporting on teachers’ experiences, Squires and Sinclair (1993) reported that teachers very strongly felt the absence of visual cues. Given the importance of non-verbal exchanges in communications generally, this is hardly surprising. Changes required to teaching via telematics included:

- reliance on diagrams using the electronic classroom;
- need for clear instructions;
- increased verbalisation;
- accurate time allocation and management;
- student centred approaches;
- questioning strategies;
- use of printed materials for a discussion focus; and
- advance planning.

**Patterns of classroom discourse**

There is a uniformity in reports of pedagogies adopted in telematics classrooms. That a great deal of didactic teaching occurs, appears to be widespread across contexts and locations. Observations of classrooms in Western Australia (Oliver & Reeves, 1994) and in Victoria (Evans & Nation, 1993) affirm that the pedagogies adopted by teachers using the technology are limited, interrogative and didactic, not conducive to searching or deep level inquiry by learners and narrow in range and focus. As a result, telematics classrooms tend to have a number of clearly identifiable characteristics and discourse patterns. Teachers tend to take prime responsibility for setting the academic agenda, organising lessons and directing student behaviour.

Consequently, classroom discourse is adversely affected, with students merely reproducing knowledge, or responding to questions posed by a teacher. The resulting pattern is one of initiation (I) by the teacher, response by a student (R) and evaluation (E) by a teacher. This IRE pattern has been acknowledged as typical of teacher fronted classrooms (Cazden, 1988; Edwards & Mercer, 1987; Mehan 1979). Not only do teachers talk more than students, they also control turns at talk. Opportunities for initiation, student-generated questioning and inquiry are constrained by this formalised pattern.

In summary, the literature (McLoughlin & Oliver, 1995) confirms that telematics environments tend to have the following characteristics:

1. passive rather than active learning;
2. teacher control over the pace, sequence and form of the lesson; and
3. learner dependence and lack of initiative.

Clearly there are challenges to the implementation of a successful academic talent program using telematics as a medium for delivery. It will be argued here that effective development of programs for gifted and talented students must be based on:

- a coherent and well grounded perspective on higher level thinking skills;
- technology use which is based on an extended classroom model;
- legitimisation of students as active participants.

Each of these aspects of educational practice will be discussed in relation to telematics delivery.

**Higher level thinking skills: A communicative perspective**

What are higher level thinking skills and what challenges do they present to the telematics teacher? Thinking is inherent in all academic tasks which involve reading, writing, arithmetic and problem solving. For example, writing involves the ability to analyse, synthesise and organise information, in addition to being able to monitor one’s own performance.

Another view of higher level thinking comes from Resnick (1987) who claims that while higher order thinking cannot be defined exactly, it is recognisable when it occurs. Some of its essential properties are that it is:

- non-algorithmic;
- complex;
- self-regulated;
- effortful; and
- applies multiple criteria.

Students demonstrate higher level thinking when problems are exposed which cannot be solved through recall and application of previously learnt knowledge. What is required for problem solving is a form of creative thinking or “going beyond the information given” (Bruner, 1971).

Higher level thinking is regarded as a desirable educational goal as it is linked to achievement, effective problem solving capacity and greater self-realisation (Rowe, 1993; Mayer, 1992). The contexts that produce higher level thinking are diverse, and include processes of reading and mathematical understanding. Thinking skills are teachable and learnable, and processes that are regarded as influential
in cultivating thinking and reasoning skills in the classroom are communicative strategies and active learning such as:

• engagement in collaborative learning processes;
• mediation by the teacher, as opposed to directing and conveying information;
• use of language by learners to convey concepts, feelings and ideas;
• encouragement of student reflection on their experiences and the effectiveness of learning;
• enabling students to engage in rational inquiry and provision of reasons and justification for their beliefs; and
• encouraging questioning in response to knowledge.

Discourse which involves a high level of learner initiation may be indicative of higher order thinking, but responses to teacher questions rarely provide anything beyond a display of content knowledge. Previous research provides evidence that the following categories of talk are productive and supportive of thinking:

• explanations and elaborations (Webb, 1989; King 1992);
• specific questions and counter assertions (Meloth & Deering, 1994);
• question generation (Hilton, 1990; Graesser, 1994);
• detailed explanations of problem solving behaviours (Webb, 1991);
• giving elaborate explanations to peers (Webb, 1989);
• task related questioning and strategy elaboration (King, 1989);
• guided co-operative questioning (King & Rosenshine, 1993); and
• giving and receiving elaborated help (King & Fanvar, 1994).

There is a well recognised need for educators to focus their efforts on improving these higher-level cognitive skills to enable learners to become independent and productive thinkers. Talented and gifted students clearly need not only an understanding of subject matter, but also communication skills and analytical strategies that are transferable across subject boundaries.

Two main theoretical frameworks contribute to the legitimisation and value of talk in learning. The social constructivist theory of Vygotsky (1978) which has recently been applied to learners’ joint activity at computers (Mercer, 1994), highlights communicative processes whereby technology mediated learning activities are set up and carried out by teachers and students as joint social interaction. This focus on shared or collaborative action is reinforced by cooperative learning theory which applies social learning theory to practical instruction. It is proposed that when students work cooperatively, and use language to share ideas, resolve conflict and expand ideas, academic and social behaviours become more interactive and result in a higher level of thinking (Schachar & Sharan, 1994; Slavin, 1990).

**Technology use and the extended classroom model**

Clearly, pedagogical outcomes relating to higher level thinking require particular patterns of interaction which foster active learning. Teachers need to use a range of strategies to engage students in remote classrooms and be aware of the impact of their practices on student behaviours.

Technology can be used to support learning rather than merely mediate communication, or act as a conveyer of the teacher’s instructions. Computers of themselves, do not transform the learning experience. We need a pedagogy to include technology use that becomes the focus for curriculum action. For telematics classroom, the “extended classroom model” (Burge and Roberts, 1993) would seem to offer advantages for gifted and talented students, as it is based on a number of educational practices which utilise the technology in support of student learning, autonomy and higher level thinking skills. It involves changes to didactic teacher centred patterns of interaction that have been found to characterise telematics classrooms (Oliver and McLoughlin, 1997). It is characterised by fundamental changes in perspective from:

- a view of learning confined to the classroom and controlled by the teacher, to one of a learning environment which is supportive, extended and distributed, consisting of a community of learners;
- a view of technology as a tool or as a teacher, to a view of computers as resources which can display creative ideas, provide a resource for inquiry, and extend thinking by bringing together students from different locations;
- a view of learning as individualised, to one which is communicative, shared and dynamic;
- a preoccupation with teaching “content” to multiple sites simultaneously to allocating responsibility to small groups for self monitoring and sharing of ideas, and analysing content, ideas and experiences.

Adoption of the extended classroom model will encourage teachers to create opportunities for higher order thinking skills by giving students more responsibility for their learning and by fostering communication between remote sites using the communications networks. Teachers can oversee social interaction in groups to ensure that there is equal participation between the remote schools. Alternatively, creative forms of leadership where students take control can be encouraged, rather than teacher initiated discourse.

Students as active participants: a framework for higher order thinking skills

For teachers engaged in telematics delivery, it is essential to reflect on the basic processes that occur in the classroom and to assess the degree to which the pedagogy and tasks contribute to the development of higher level thinking skills. Teachers can be alert to classroom practice by asking:

- How do high ability students respond to the tasks and activities in my lessons?
- Are these learners engaging in higher order cognitive processes, problem generation, reasoning and critical thinking?
- What teaching strategies can I use to establish meaningful learning experiences for students to develop higher order learning?

For teachers, some of the major issues that need to be considered are as follows:
1. Their role in the learning process. To what extent is the teacher an authoritative provider of knowledge as opposed to a resource? What additional roles could teachers perform, other than to initiate questions and manage the lesson?

2. Role of the student. How can students demonstrate autonomy, self direction and ownership of the activities throughout the lesson? How can they be encouraged to engage in higher order processes such as evaluating and problem solving?

3. Teaching strategies. What teaching methods and corresponding activities should be used to achieve the instructional goals of higher order learning? How should these activities be sequenced to optimise learning?

Telematics environments have the potential to foster self-directed and autonomous learning through appropriate use of the technology and the orchestration of appropriate interactions with learners.

A preliminary step in the creation of a framework to guide telematics teachers is to specify the essential functions a learner must engage in to learn from instruction. This places the learner at the centre of the activity, and learning, as opposed to teaching becomes the focus. The objective is to change the asymmetric pattern of interaction observed in telematics classrooms (McLoughlin & Oliver, 1995) where teacher talk tends to suppress opportunities for student initiative and eliminate communication, exchange of views and elaboration of ideas between students.

The framework is intended to enable teachers to help learners take appropriate steps to control their learning by creating opportunities for dialogue and reciprocal action. The aim is to orchestrate the learning experiences so that increased learner action and communication are fostered. In this way, the telelearning environments can bring about progressive, social, interactive participation where learners can develop cognitive and metacognitive strategies to enhance their own learning. Table 1 below represents those functions which the teacher initiates in order to bring about learning, but most importantly, shows that at every stage the learner must also be engaged in a reciprocal action, and may also initiate dialogue.

### Summary and conclusions

This article began by noting the limitations of telematics environments, and the didactic teaching style adopted by many teachers as they try to accommodate their teaching styles to the medium. In order to maximise use of the technology for delivery of lessons to remote learners while meeting the requirements of the academic talent program, the emphasis has been on self directed learning and authentic interactions as key strategies to meet the outcomes of higher order thinking skills. The focus of the framework is to enable the teacher to create an environment which is meaningful to students, enabling them to take responsibility, pose questions and self-evaluate their own learning. The verbal skills and strategies that students employ are key elements of the framework as it is through the discourse of such verbalisation that higher order cognition can be evaluated.

Three elements were identified as important to teacher pedagogy for talented and gifted student learning via telematics. Firstly, teachers need to have a clear idea of what higher level thinking skills are, and how they are demonstrated through discourse. It was proposed that a communicative theory of learning and teaching based on socio-cultural theory provides a sound basis for telematics classrooms, as listening and speaking skills are fundamental to the interactions that occur. Secondly, the adoption of an extended classroom model will provide teachers with a broader and socially based perspective on learning, where learners contribute to, and support the learning process, and technology acts to bridge the distance. Thirdly, a clear focus on learners as active participants will enable the teacher to plan lessons where a range of communicative functions are initiated by learners.

The framework is only a starting point for developing higher order thinking skills. Observations of the learners as they engage in problem generation, critical analysis, consideration of alternative solutions and evaluation of alternative perspectives will lead to better understanding of how telematics environments can be designed to enhance higher order learning.

### Table 1: Guided learning model to promote higher order learning

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>TEACHER INITIATED</th>
<th>STUDENT INITIATED</th>
<th>LEARNER ROLE/ STRATEGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesson objectives</td>
<td>specify instructional outcome</td>
<td>identify or state purpose of learning</td>
<td>self-direction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>state expectations</td>
<td>(metacognitive)</td>
</tr>
<tr>
<td>Building on prior knowledge</td>
<td>discuss context, investigate level of understanding</td>
<td>present examples, discussion and brainstorming</td>
<td>learning strategies, mnemonics</td>
</tr>
<tr>
<td>Scaffolding</td>
<td>teacher intervenes when the learner requires help</td>
<td>students scaffold each other by listening and discussion</td>
<td>building a sense of community</td>
</tr>
<tr>
<td>Modelling</td>
<td>teacher thinks aloud and displays thinking processes</td>
<td>students think aloud and share ideas</td>
<td>developing awareness of higher level thinking skills</td>
</tr>
<tr>
<td>Supporting student responses</td>
<td>explain, cite examples, contextualise</td>
<td>generate examples, create images</td>
<td>elaboration, verbal extension</td>
</tr>
<tr>
<td>Questioning</td>
<td>asks questions, checks understanding</td>
<td>self questioning, hypotheses generation, asking “what if?” questions</td>
<td>stimulation of curiosity, internal processing</td>
</tr>
<tr>
<td>Feedback</td>
<td>provide positive and negative feedback, correct responses</td>
<td>group monitoring, self testing</td>
<td>self regulation</td>
</tr>
<tr>
<td>Evaluation</td>
<td>ask students to evaluate their own performance</td>
<td>express what is known, not known identify gaps in understanding</td>
<td>personal causation and involvement</td>
</tr>
</tbody>
</table>

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