INTRODUCTION

Teachers electing to incorporate microcomputers in their programs are faced with the challenge to apply current views that learning:

- is an active process in which meaning is constructed in the mind of learners; it is not a simple act of taking on another person's meanings without any internal processing;
- is a dialogue between existing knowledge and new information to shape new knowledge;
- is under the control of learners, hence must meet the needs of learners for them to engage effectively with any learning situation;
- involves the total person and hence relates to the learner's feelings about self, learning, the context, and the content;
- involves error making and demands support for utilising error as a source of information;
- involves a trusting relationship between co-learners and between learners and teacher/mentors/models;
- is enhanced by reflection upon personal learning processes and an articulation of them to increase conscious control over them, i.e. metacognition.

(After Davis 1986, p. 11)

In an examination of artificial intelligence development, Cumming (1990, pp. 319-25) debates one possible direction to take. In the design of intelligent educational systems, which are seen as computer systems intended to support a wide variety of learning interactions, he advocates two levels of learner involvement: a Task Level where learners actively use a computer facility to engage tasks which are important to them; and, a Discussion Level facilitating explanation and guidance which provides the opportunity for reflection.

While such sophisticated on-machine systems are being developed, there may be other solutions to the problem of providing a discussion level and accommodating current principles of learning. This article reports a study which raises the possibility of making more use of student talk where learners are collaborating in small groups and working with software which gives reasonable control to the learner. Such software would include adventure games, simulations, programs emphasising problem solving and decision making, and various tools such as databases, HyperCard, spreadsheets, word-processors.

One of the learner's most powerful means for shaping their experience and structuring their knowledge is their personal language. Dillon (1985) notes:

We know by structuring and we structure by uttering or writing. Thus, much of children's learning results from conversational interaction with others in a collaborative meaning-making enterprise. In talking with parents, friends, and so on, children initiate, question, challenge, transform and confirm — all helpful strategies in learning. (p. 90)

The important role that interactive talk plays in learning has received considerable attention in the literature e.g. Barnes (1976, 1977), Tough (1977, 1979), Wells (1981, 1986), and Chang and Wells (1987). Barnes and Todd (1977) explain that open talk contains features such as invitations for personal opinions, evidence of hypothetical reasoning, exploratory discussion, doubting, questioning and posing of contradictory statements and uncertainties, as individuals grope towards making meanings. The strategies which children engage naturally in talk enable them to think over new information, self-correct, modify thought and reflect on personal knowledge in the light of information available to them. Barnes (1976, p. 31) regards the learner during open-conversational talk as an active participant in the making of meaning: the process of reshaping knowledge to make it personally relevant gives the student authoritative control over learning.

Meanwhile the benefits to be gained from cooperative and collaborative classroom activity have been well argued and documented, notably by Cagan (1978) from a philosophical and social standpoint, and by Johnson and Johnson (1985), Johnson, Johnson and Stanne (1985), Watson (1991), and Salmon (1980, 1984) from pedagogical and psychological points of view. Moreover, Sheingold et al. (1982) and Chandler (1983) both reported studies which indicated that the deployment of computers in classrooms, far from isolating students at the keyboard, actually increased the amount of talk and collaborative activity. Little research, however, has contributed to our knowledge of the nature of this talk.

Accordingly in a project funded by a Social Sciences Research Grant at the University of Queensland, we set out first to confirm that the computer environment does foster talk. Second, we sought to identify the kind of talk generated by small groups of upper
primary and lower secondary school students using computer software which was designed to encourage higher-level thinking skills and which centred on problem solving and decision making. The variation in language use among groups of different sizes and gender mix also received our attention.

Only two small studies appear to have investigated language in the context of collaborative use of classroom-based microcomputers. Cummings (1985, p. 149) concluded that the microcomputer can act as 'a quiet catalyst in the learning environment' by motivating and facilitating the language of group work. Carrier and Sales (1987) studies patterns of verbal interaction within groups working on computers. They found that students were on task 77 percent of the time and that students in pairs sought more elaborative explanations than did individuals.

Similarly, little research seems to have been conducted on the optimum size of groups working at the keyboard, clearly a physically restricted environment. Light et al. (1987) investigated microcomputer use in the context of collaborative settings. While concluding that the computer had the capacity to stimulate active collaboration and discussion among children aged eight to eleven, the study made no firm recommendation on group size. Our interest in the gender composition of such groups was further fired by a paper delivered at the recent World Conference on Computers in Education in which Clarke (1990) sought to dispel what she saw as seven myths about women and computing. The myths as she saw them included girls are not good at computing and gender differences in computing experience are substantial.

**FIRST STAGE — THE PILOT**

Spreadbury (1989), a postgraduate student working in the ambit of the project, conducted a study into the nature of the talk generated by Year 6 primary school students while working in groups with two simulation software programs of the adventure game genre, namely, *Where in the world is Carmen Sandiego?* (Broderbund) and *Dinosaur Discovery* (Jacaranda).

Students from a southside suburban state school were allotted at random to nineteen single-sex and mixed groups of two, three and four students. The talk generated in twenty-five minute sessions was recorded on audio-tape and the 7 hours 55 minutes of talk analysed using Tough’s (1979) classification of language use (shown in Figure 1).

**Self-maintaining and group maintaining strategies**
1. Referring to physical and psychological needs and wants of the self or the group.
2. Protecting the self or group and self or group interests.
3. Justifying behaviour or claims of self or group.
4. Criticising others.
5. Threatening others.
6. Asserting superiority of self or group.

**Directing strategies**
1. Monitoring own actions.
2. Directing the actions of the self.
3. Directing the actions of others.
4. Collaborating in action with others.

**Reporting on present and past experiences strategies**
1. Labelling the components of the scene.
2. Referring to detail (e.g. size, colour and other attributes).
3. Referring to incidents.
4. Referring to the sequence of events.
5. Making comparisons.
6. Recognising related aspects.
7. Making an analysis using several of the features above.
8. Extracting or recognising the central meaning.
9. Reflecting on the meaning of experiences, including own feelings.

**Reasoning strategies**
1. Explaining a process.
2. Recognising causal and dependent relationships.
3. Recognising problems and their solutions.
5. Reflecting on events and drawing conclusions.
6. Recognising principles.

**Predicting strategies**
1. Anticipating and forecasting events.
2. Anticipating the detail of events.
3. Anticipating a sequence of events.
4. Anticipating problems and possible solutions.
5. Anticipating and recognising alternative courses of action.
6. Predicting the consequences of actions or events.

**Projecting strategies**
1. Projecting into the experiences of others.
2. Projecting into the feelings of others.
3. Projecting into the reactions of others.
4. Projecting into situations never experienced.

**Imagining strategies**
1. Developing an imaginary situation based on real life.
2. Developing an imaginary situation based on fantasy.
3. Developing an original story.

Figure 1 Uses of language and supporting strategies (Tough, 1979)

Students spent a considerable 93 percent of their time talking. Moreover, direct observation suggested that most of the pauses could be explained by the need to keyboard responses to the programs. There was little evidence, and certainly no significant evidence, that the size and gender composition of the groups made any difference to the time spent talking or to the type of language used.

Spreadbury (1989a, p. 19–20) reported: A variety of language uses was evident from the children’s talk. By far the greatest amount of time talking was spent in directing. However, the greatest proportion of time in this mode was spent in both collaboration and monitoring the groups’ actions, not in directing the actions of the self or others. There was frequent use of ‘we’ and not ‘I’ throughout the group conversations. Of particular interest was the very small amount of total time (2.92%) spent by the children in the self and group maintaining mode, e.g. asserting one’s
superiority or threatening others. Five
out of the seven types of talk as classified
by Tough were used by the class. While
no instances of projecting and
imaging were evident, directing took
up 63.34% of the time spent talking,
reporting 26.8%, reasoning 5.14% and
predicting 1.76%.

SECOND STAGE – THE PARTICIPANTS
In 1988/89, Year 8 students at a Brisbane
southside state secondary school were
allotted at random to seventeen groups
which worked with three
mathematically-based pieces of
computer software emphasising
problem solving. Table 1 shows the
distribution by group size and gender
mix.

The software
Three pieces of computer software
which emphasise problem solving were
selected. All three are publications of
Sunburst Communications.

Puzzle Tanks is a game of
numbers and logic. Students are given
two tanks, each of a set capacity that is randomly
chosen by the computer, and a storage
tank. The challenge: by filling tanks,
emptying tanks, and transferring from
tank to tank such materials as ‘Jelly
Juice’ and ‘Yerple Paint’, students must
finally arrive at a target amount (also randomly chosen by the computer)
in the storage tank. Three difficulty levels
plus a championship level give students
an ever increasing challenge. Students are
scored according to the number of
tries it takes them to complete the
problem, and can compete with each
other to find the most efficient way to
solve a problem. Creative use of colour
graphics and animation are features of
the program.

The Enchanted Forest is a
mathematics fairytale adventure that
requires students to think logically and
understand concepts of conjunction
(and), disjunction (or), and negations
(not). Students enter the enchanted
forest to find strange looking ponds
that contain geometric shapes. Students
must first identify the attributes of those
shapes — type of figure, size, colour —
for they soon discover that the evil
witch has taken all the animals in the
forest and turned them into the strange
looking shapes that they had seen in
the ponds. To release the animals, students must learn (at the witches’
school) to describe all the shapes in the
ponds as sets involving conjunctions,
disjunctions and negations.

Randomly created ponds make the
game playable again and again.

Factory uses colour graphics and
animation to challenge students to
create geometric products off a
simulated machine assembly line which
they design. Students are required to
use inductive thinking and integrate
their skills in visual discrimination,
spatial perception, understanding
sequence, logic and efficiency. The
program has three levels:

1. Test A Machine — Students test
   the effects of three electronically
   simulated machines on a raw
   material.
2. Build A Factory — In this second
   level, students set up an assembly
   line and watch it produce a product.
3. Make A Product — Students now
   face the challenge of building a
   factory to duplicate a product
   shown on the screen.

Data collection and analysis
Following the experience gained in the
pilot study, it was decided that while
audio-taping was adequate for
recording talk, video-taping would
supply more information for the wider
purpose of deducing what cognitive
skills were operating. Some of the
visuals on screen were recorded directly
from the computer, but a number of
technical difficulties due to the
incompatibility of PAL and NTSC
television systems meant that over half
the groups had to be videotaped by
camera. Observation of, and later
interviews with, students suggested the
intrusion of a camera did not distract
students to any great degree. Each
group was recorded during a twenty-
five minute session.

Students’ use of language was
analysed using Tough’s (1979)
categories, namely, self-maintaining
and group-maintaining, directing,
reporting on present and past
experiences, reasoning, predicting,
projecting, and imagining. The group
talk was classified in units of ten
seconds, the most typical language use
during the ten-second interval being
that recorded. Additional categories
were used to denote units where a
language use could not be identified
and where there was no talk.

Findings
Tables 2, 3 and 4 show the percentages
different language uses generated
by each of the three pieces of software
respectively.

Table 1 Allocation of Groups to
Computer Software by size and gender
mix

<table>
<thead>
<tr>
<th>SOFTWARE/ GROUP SIZE</th>
<th>PUZZLE TANKS</th>
<th>ENCHANTED FOREST</th>
<th>FACTORY</th>
</tr>
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<tbody>
<tr>
<td>Pairs</td>
<td>Males</td>
<td>Males</td>
<td>Males</td>
</tr>
<tr>
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<td>Females</td>
<td>Females</td>
<td>Females</td>
</tr>
<tr>
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<td>Mixed</td>
<td>Mixed</td>
<td>Mixed</td>
</tr>
<tr>
<td>Threes</td>
<td>Males</td>
<td>Males</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>Females</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fours</td>
<td>Males</td>
<td>Males</td>
<td>-</td>
</tr>
<tr>
<td></td>
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<td></td>
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Table 2 Percentages of language use stimulated using Puzzle Tanks by group size and gender mix

<table>
<thead>
<tr>
<th>GROUPS/ LANGUAGE USE</th>
<th>PAIRS</th>
<th>THREEs</th>
<th>FOURS</th>
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<tr>
<td></td>
<td>Male</td>
<td>Female</td>
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<tr>
<td>Self Maintaining</td>
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<td>2.5</td>
<td>2.5</td>
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<td>Directing</td>
<td>30.7</td>
<td>23.4</td>
<td>23.4</td>
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<tr>
<td>Reporting</td>
<td>17.7</td>
<td>2.3</td>
<td>2.5</td>
</tr>
<tr>
<td>Reasoning</td>
<td>31.6</td>
<td>53.1</td>
<td>36.9</td>
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<td>Predicting</td>
<td>10.2</td>
<td>14.8</td>
<td>14.8</td>
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<tr>
<td>Projecting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imagining</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unidentified</td>
<td>8.4</td>
<td>6.3</td>
<td>18.5</td>
</tr>
<tr>
<td>Pause</td>
<td>1.2</td>
<td>2.5</td>
<td>3.6</td>
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AUSTRALIAN EDUCATIONAL COMPUTING, MAY 1992 37
Table 3 Percentages of language use stimulated using Enchanted Forest by group size and gender mix

<table>
<thead>
<tr>
<th>GROUPS/LANGUAGE USE</th>
<th>PAIRS</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
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<tr>
<td></td>
<td>Male</td>
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<tr>
<td>Self Maintaining</td>
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<td>13.1</td>
<td>5.6</td>
<td>1.2</td>
<td>30.4</td>
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<tr>
<td>Directing</td>
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<td>34.3</td>
<td>30.9</td>
<td>22.2</td>
<td>21.1</td>
<td>15.8</td>
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<td>Reporting</td>
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<td>17.9</td>
<td>25.5</td>
<td>29.3</td>
<td>4.0</td>
</tr>
<tr>
<td>Reasoning</td>
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<td>2.0</td>
<td>27.4</td>
<td>4.4</td>
<td>3.5</td>
<td>6.6</td>
</tr>
<tr>
<td>Predicting</td>
<td>11.6</td>
<td>8.1</td>
<td>23.3</td>
<td>21.1</td>
<td>19.7</td>
<td>4.0</td>
</tr>
<tr>
<td>Imagining</td>
<td>15.1</td>
<td>22.2</td>
<td>9.5</td>
<td>15.5</td>
<td>23.4</td>
<td>25.1</td>
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<tr>
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<td>1.0</td>
<td>1.2</td>
<td>3.3</td>
<td>1.2</td>
<td>18.5</td>
</tr>
</tbody>
</table>

Table 4 Percentages of language use stimulated by Factory by pairs of different gender mix

<table>
<thead>
<tr>
<th>GROUPS/LANGUAGE USE</th>
<th>PAIRS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
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<tr>
<td>Self Maintaining</td>
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<tr>
<td>Directing</td>
<td>9.8</td>
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<tr>
<td>Reporting</td>
<td>24.5</td>
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<tr>
<td>Reasoning</td>
<td>51.9</td>
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<tr>
<td>Predicting</td>
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<td>Imagining</td>
<td>4.9</td>
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<tr>
<td>Unidentified</td>
<td>5.1</td>
</tr>
</tbody>
</table>

The second stage of the study reinforced the finding of the pilot stage that the computer environment generates an amazing amount of talk when groups work collaboratively at the keyboard. Figure 2 illustrates the high proportion of talk to non-talk irrespective of group size and the gender composition of the groups. The least amount of talk occurred in the groups of four, yet even in that configuration talk consumed 94.3 per cent of the time. (Figure 2)

As in the pilot study, students used the same five of Tough's (1979) categories of language use; again no instances of projecting and imagining were found. Students remained constantly on task. Only a small percentage of time (4.4%) was spent in self and group maintaining. The software emphasising problem solving which was used in the second stage did not foster the disproportionate directing behaviour of the pilot study, but stimulated much more reasoning and predicting activity (see Figure 3(a)).

As illustrated in Figure 3(b), there was little difference between the language uses employed by pairs and groups of three. Perhaps there is a hint that more reasoning occurs in pairs. Groups of four, however, spent much more time on self and group maintaining and far less in predicting.

Overall, males and females produced similar patterns and percentages of language use (see Figure 4). If anything, groups of mixed-gender composition used more reasoning, 28.9 per cent of the time contrasted with 17 per cent for males and 21.3 per cent for females. (Figure 4)

While pairs and groups of three showed similar patterns and percentages of language use for males and females, there are some marked differences between the groups of four (see Figure 5). Females appear to be the more cooperative in this type of setting.
Males spent much more time on self and group maintaining, while females clearly reported and predicted considerably more than males. In addition, females displayed a tendency to reason more often. These trends in language use reported for groups of four need to be treated with some caution: 26.9 per cent of the talk by males and 74.7 per cent by females could not be categorised because of the technical difficulties associated with recording multiple voices in such a restricted environment.

CONCLUSION

It is clear that the collaborative use of microcomputers generates a substantial amount of talk. With mathematical problem-solving software such as that used in the second stage of this study, the talk is directed into on-task language use involving reporting, reasoning and predicting.

Directing played a much smaller part than it did when primary students used simulation adventure software, and self and group maintaining played only a minor role in the interaction. This was especially so with pairs and groups of three. Given this and the fact that the use of groups of four restricted individual access to the keyboard, the study suggests the use of pairs and groups of three would be better choices for group work with the computer.

The gender make-up of groups would seem to make little difference to the time spent talking and to the type of talk used. Mixed pairs, however, show a tendency to use reasoning more often, while girls in groups of four appear to cooperate more with one another. There
would certainly appear to be no disadvantages for girls if teachers adopted such computer-oriented strategies.

Indeed the outcomes of this project to date suggest that microcomputer environments are capable of sustaining worthwhile talk, especially when pairs or groups of three collaborate while working with software which is not developed on behaviouristic learning theory. The crucial role that collaborative conversational talk plays in learning reinforces our view that small-group work with the microcomputer is an admirable way to help operationalise currently accepted principles of learning.

REFERENCES
Spreadbury, R. (1989), The computer as catalyst, Quick no. 32, pp. 18–20.