Appendix B – Multimodal Discourse Analysis Summary of Data

Appendix B Part A – Learning Episodes

This appendix presents descriptions and analysis of the 24 learning episodes examined as part of the multimodal discourse analysis. Summaries of the discourse codings for each learning episode are provided and related to qualitative observations regarding the implementation of each lesson. The results of all intra-topic analysis have been included in this Summary of Data section so that the reader may more easily relate those results to the data.

Two limitations of the dataset including a problem with the recording of the screen-share in the group programming activity of Topic 3 and a re-recording conducted for the shallow versus deep programming activity in Topic 9 Iteration 3 are discussed following the description of the learning episodes. The problem with the screen-share is considered to introduce an error to the dataset of at most 0.1%, while the re-recording is assumed to be within the natural variation of implementing a particular interface and learning design. This is explained in more detail in the section after the learning episode descriptions.

This is followed by a section containing the details of all statistical tests including null and alternative hypotheses, the types of tests applied, the results of test statistic calculations and the inferences of the test results. As well, details of Bonferroni adjustments to significance levels are provided to account for the fact that some tests incorporate multiple sub-tests.

Finally, an example transcript (Topic 1, Iteration 1) has been provided to 1 to illustrate the nature of teaching and learning in the web-conferencing environment as well as the transcription process applied.

As previously noted, all between topic and global results have been included in the Multimodal Discourse Analysis Results chapter (Chapter 5).

The eight Topics and the details of their three Iterations are now presented.

Task 1 – "Debugging Cube Program" (from Topic 1)

Learning Task Analyzed: Debugging Task (Procedural)

Question:
(From Horstmann, 2003 Lab Exercise L1 Q10-14)
There are numerous opportunities for error in any program, often times in places that seem too simple to require close attention. The process of finding errors in programs is called "debugging".

a) What do you think the following program is meant to output?

```
public class Cube
{
    public static void main()
    {
        double height = 3.0;  \\ centimeters
        double cube_volume = height * height * height;
          double surface_area = 8 * height
          System.out.println("Volume = " cube_volume);
        System.out.println("Surface area = " + surface_area;
}
```

b) Will this program work as shown? If not, what problems can you identify.
c) Try compiling the program. What happened?
d) Fix the syntax errors so that the program compiles and runs.
e) The program has a logical error. What is it? Find and fix it.

Approaches:
All three semesters used a teacher-centred approach where students made suggestions about how to rectify problems in the program to the teacher who was sharing his screen. The teacher poses questions, prompts students for responses, and makes amendments to the program directly into the Integrated Development Environment.

Using screen-sharing to model the practice of programming allows students to acquire procedural knowledge associated with learning to program. It is particularly important that students observe how to program in the first weeks of the course. For instance, through this activity students were able to observe the iterative process of program debugging.

This is the only task of the eight selected where the same approach is used throughout all three semesters. The reason that the same (teacher-led) approach was used in all three semesters for Topic 1 is that while more collaborative, student-centred learning designs were used in Iteration 2 and 3 for other Topics, the teacher felt it appropriate to use a less technologically demanding approach to fostering learning in the first week of all semesters so that students could concentrate on learning to program. This common approach across all three semesters for this Topic provides an opportunity to inspect the similarity of discourse between semesters when the same learning design is used, i.e., provide a means of calibration.

Learning Episode 1 (Topic 1 – Iteration 1)

Activity Design: Teacher-Led Programming (Debugging)
Interface Design: Presentational
Number of students: 9
Duration: 7 minutes

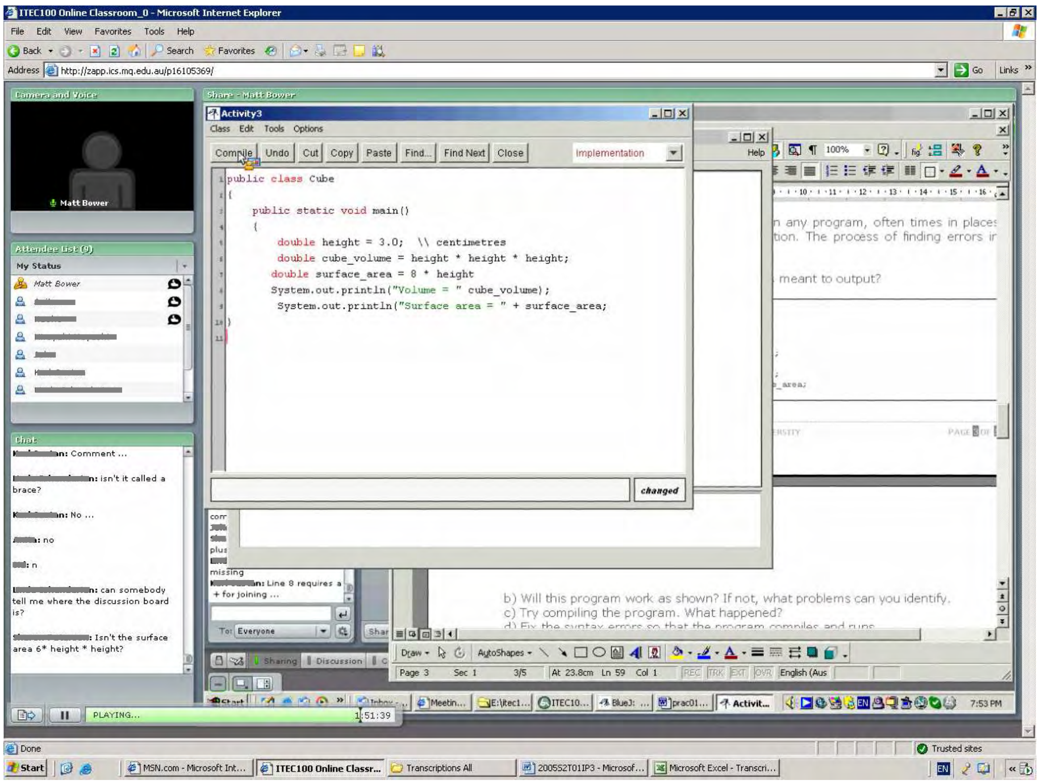


Figure 131 – Interface for episode in Topic 1 Iteration 1

Summary of episode:
This iteration used the default web-conferencing screen-sharing layout to broadcast the teacher's Integrated Development Environment (see Figure 131). Note that the text-chat pod was being rebroadcast in the lower left corner because this was the only way that the teacher knows how to see the students' text-chat comments while he is sharing his screen (the teacher is unaware that if they minimize the web-conferencing browser window while they share the screen text-chat messages will automatically pop up). The double broadcast of the text-chat pod was more pronounced at other times throughout the lesson, and led to less efficient teacher communication (due to restricting the size of the possible broadcast area, and having to ensure that windows do not cover the text-chat pod). This worked against the redundancy principle and causes additional extraneous cognitive load.

A standard pedagogical pattern was adopted, whereby the teacher questions students about a presented artefact (computer program) and students respond with their answers. This is represented in Table 39 and Table 40 below by five teacher independent questions and 13 student statement response to questions. The teacher communicated using audio (68 sentences, ref. Table 32) while students used text-chat (27 sentences, ref. Table 33). The text-chat allowed several student comments to be simultaneously contributed in response to any teacher question, leveraging the non-interfering affordances of the text-chat with other text-chat comments or audio contributions. The teacher-led learning design obviated the need for students to contribute any comments related to the coordination of activity.

The procedural nature of the task allowed practical and applied knowledge to be developed. The learning design incorporated a dynamic and interactive element through the teacher's use of student suggestions to rectify errors in the program. This "expert modelling" instructive approach is represented in Table 32 by the 27 teacher actions associated with modelling programming which were recorded. This also involved three instances of moving information between resources (for instance, computer code from a Word document to the Integrated Development Environment) which served to demonstrate to students how such shifting of code between sources may be achieved.

The affordances of the screen-share modality allowed the nature of programming to be represented in a way that most efficiently corresponds to the way in which students would be expected to apply their knowledge, which is in accordance with Symbol System Theory (Salomon, 1994). While the text-chat was an efficient way to capture the whole class' responses, it is difficult to assess the formedness of student mental models beyond the multi-structural level because the modality does not support comprehensive interrelationship of knowledge units.

T01_2005S2	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	**Totals**
Content	5	22	1	1	3	11	0	8	**51**
Activity	0	3	0	0	0	0	0	0	**3**
Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content	1	1	0	0	0	0	0	0	**2**
Activity-Technology	0	1	0	0	0	0	0	0	**1**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	3	0	0	1	3	0	1	**8**
Unrelated/Unclassifiable	0	3	0	0	0	0	0	0	**3**
Totals	**6**	**33**	**1**	**1**	**4**	**14**	**0**	**9**	**68**

Table 39 – Topic 1 Iteration 1 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T01_2005S2	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	**Totals**
Content	1	0	0	2	13	3	0	1	**20**
Activity	0	0	0	0	1	1	0	0	**2**
Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content	0	0	0	0	0	0	0	0	**0**
Activity-Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	0	0	0	0	1	0	0	**1**
Unrelated/Unclassifiable	1	0	0	0	1	2	0	0	**4**
Totals	**2**	**0**	**0**	**2**	**15**	**7**	**0**	**1**	**27**

Table 40 – Topic 1 Iteration 1 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Learning Episode 2 (Topic 1 – Iteration 2)

Activity Design: Teacher-Led Programming (Debugging)
Interface Design: Presentational
Number of students: 11
Duration: 6.25 minutes

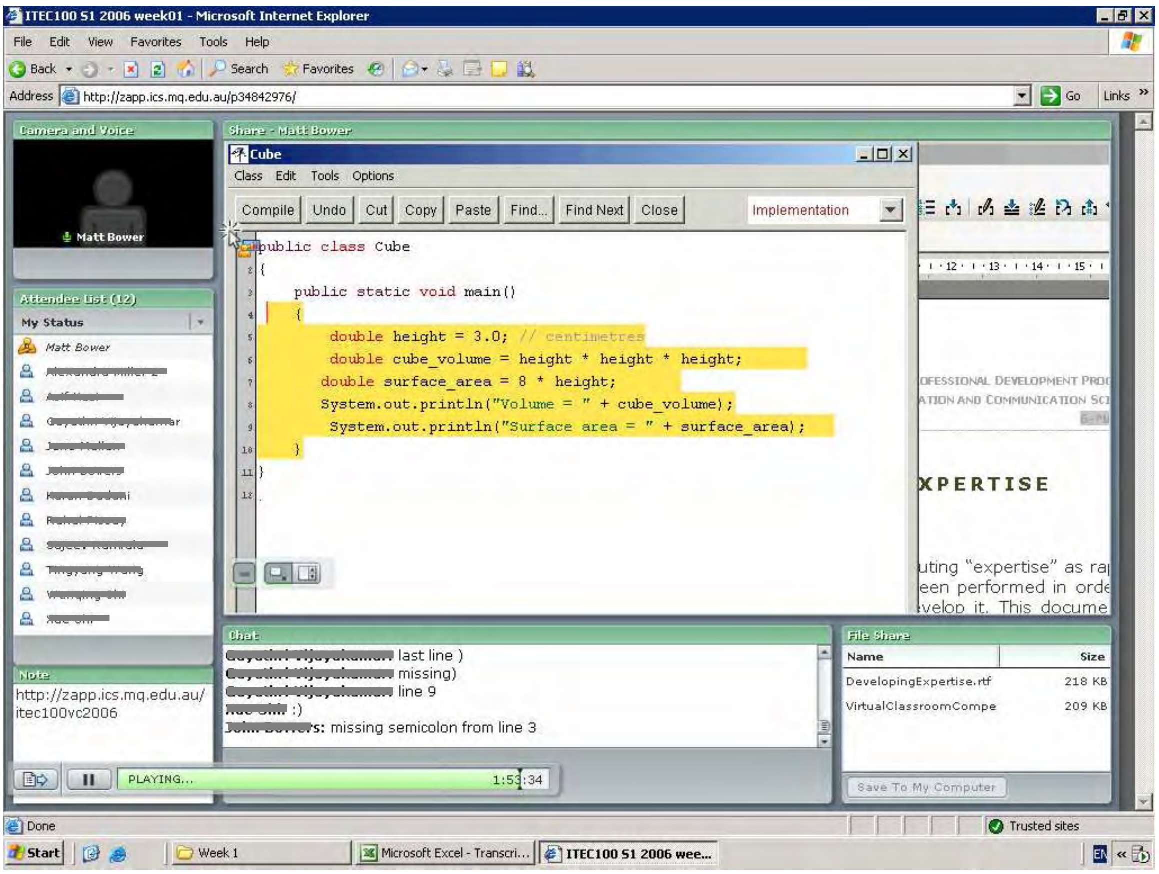


Figure 132 – Interface for episode in Topic 1 Iteration 2

Summary of episode:
In Iteration 2 of this task the user interface had been adjusted to make the text-chat pod larger and run across the bottom of the screen, allowing more of the students' comments to be seen at one time (see Figure 132). As well, the file-share pod had been included to facilitate transfer of programs (however this facility was not used during this learning episode). In this Iteration the teacher was aware that if they minimize their browser window the conferencing software will pop-up student text-chat messages (thus there was no need to have the text-chat visible on the screen, providing more area for the IDE).

A similar implementation to Topic 1 Iteration 1 was applied in this learning episode, whereby the teacher prompted students for suggestions regarding the activity. This was evidenced in the Subject-Interaction Tables with the teacher asking 5 Independent

Questions regarding the Content (ref. Table 41) and students making 14 Content based Responses to Questions (ref. Table 42). The teacher often took an instructive role in the episode, as indicated by the 24 Content Independent Statements (ref. Table 41). However students were engaged in the learning process, asking 3 Responsive Content Questions (ref. Table 42). Students remained on task, with no student discussion relating to matters other than the curriculum-based subject matter being discussed (apart from 3 expressions of sentiment relating to their success with the task, ref. Table 42).

As the learning design adopted in this iteration was fundamentally the same as in Iteration 1, the same issues regarding the advantages and disadvantages of text-chat for collaborating simultaneously and demonstrating the formedness of mental models once again apply. Observations regarding Salomon's (1994) Symbol System Theory are also equally appropriate.

Even though there were more students in this learning episode than in Iteration 1, there was slightly less collaboration overall. In Iteration 2 the teacher contributes 23 actions relating to modelling programming and 59 sentences using audio as opposed to 27 and 68 in Iteration 1 (ref. Table 32). In Iteration 2 students make 22 text-chat contributions as opposed to 27 in Iteration 1 (ref. Table 33). Correspondingly, this learning episode took slightly less time to implement (6.25 minutes as opposed to 7 minutes in Iteration 1). However the overall pattern of contributions appears similar in the two iterations (which is validated using a Chi-square test in the next learning episode description).

T01_2006S1	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	5	24	1	0	4	9	0	3	46
Activity	0	1	0	0	0	0	0	0	1
Technology	0	0	0	0	0	0	0	0	0
Activity-Content	2	0	0	0	0	0	0	0	2
Activity-Technology	0	0	0	0	0	0	0	0	0
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	0	0	0	0	1	4	0	2	7
Unrelated/Unclassifiable	0	4	0	0	0	0	0	0	4
Totals	7	29	1	0	5	13	0	5	60

Table 41 – Topic 1 Iteration 2 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T01_2006S1	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	0	1	2	1	14	1	0	0	**19**
Activity	0	0	0	0	0	0	0	0	**0**
Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content	0	0	0	0	0	0	0	0	**0**
Activity-Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	1	0	0	0	0	0	2	**3**
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	**0**

Table 42 – Topic 1 Iteration 2 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Learning Episode 3 (Topic 1 – Iteration 3)

Activity Design: Teacher-Led Programming (Debugging)
Interface Design: Presentational
Number of students: 2
Duration: 10.5 minutes

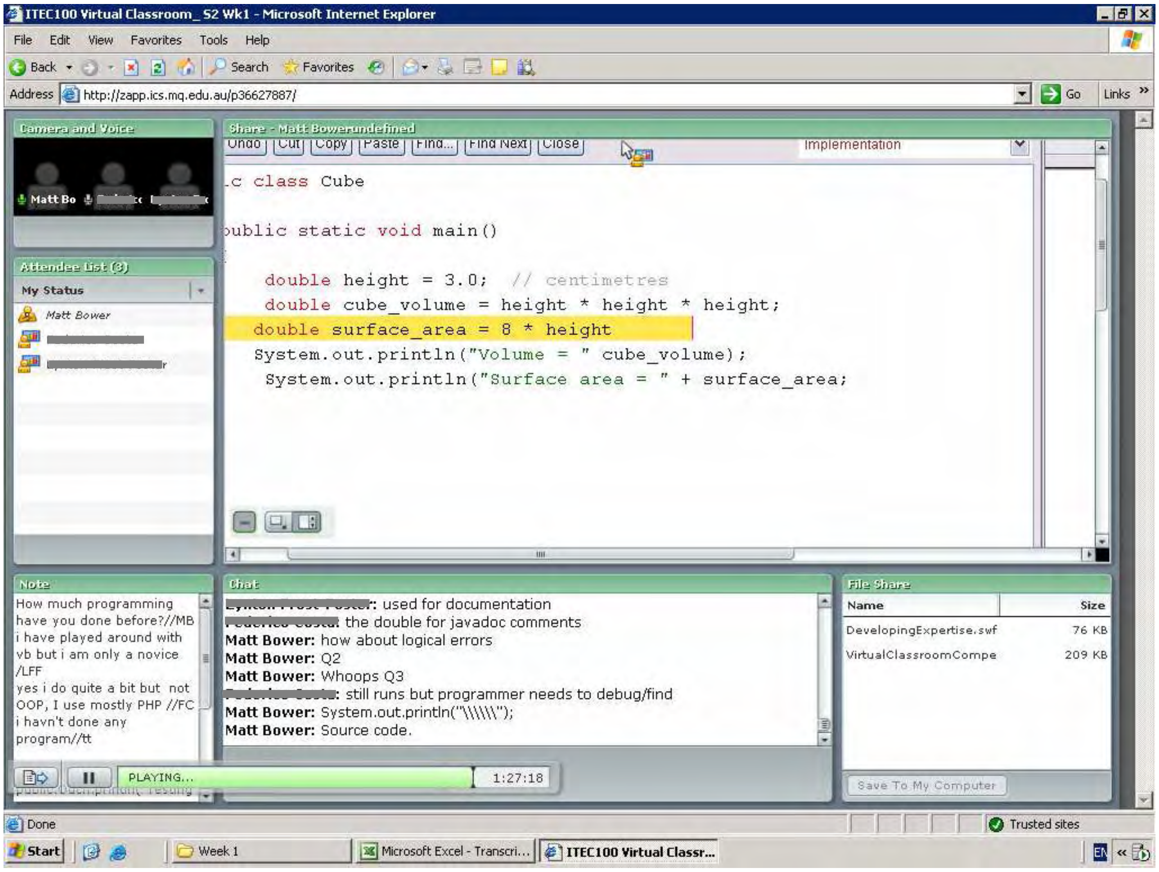


Figure 133 – Interface for episode in Topic 1 Iteration 3

Summary of episode:
The same standard interface was used for this iteration as Iteration 2, except that students used audio as well as the teacher. The fact that there were only ever two or three students in Iteration 3 classes made this feasible – to have eight or ten students using audio would have required more time to set up in the first lesson (there is usually some troubleshooting time needed to ensure all students' audio is working), and more collaborative skill to avoid peoples' audio from interfering with one another.

The teacher adopted the same approach to the task as in Iteration 1 and Iteration 2. The different number of students in this Iteration (two as opposed to 11 and 9 in Iteration 1 and 2 respectively) and the fact that students were using audio as opposed to text-chat did not appear to impact on the amount and type of collaboration. There were 26 student textual discourse contributions in Iteration 3, as opposed to 27 and 22 in Iterations 1 and 2 respectively (ref. Table 33), and once again most of those were responsive statements. There were 24 teacher actions relating to modelling programming in Iteration 3 which fell between the Iteration 1 and Iteration 2 measures (27 and 23 respectively) and although there were slightly more teacher audio contributions (76 in Iteration 3 as opposed to 68 in Iteration 1 and 59 in Iteration 2, ref. Table 32) the magnitude is similar. A Chi-square test of teacher textual discourse across the three iterations indicated no significant difference between the types of Subject-Interaction contributions ($\chi^2 = 8.964$, $p = 0.345$, d.f. = 8, ref. Statistical Test 1). Similarly, a Chi-square test of student textual discourse across the three iterations revealed no significant difference between the types of Subject-Interaction contributions ($\chi^2 = 1.591$, $p = 0.810$, d.f. = 4, ref. Statistical Test 2). This illustrates the relative consistency of collaboration that can result from similar interface and activity designs.

While the use of audio did not make any significant difference to the amount or type of discourse that transpired, audio was observed to allow easier contribution of extended items of text (people could speak faster than they could type). Voice contributions also enable easier reception of other people's comments as text-chat may be unnoticed if there is other activity occurring on the screen or an audio conversation is being held.

Iteration 3 of this learning episode took longer than in Iteration 1 or Iteration 2 (10.5 minutes as opposed to 7 minutes and 6.25 minutes respectively) mainly due to the fact that discussions regarding overloading and the mechanics of concatenation arose. This illustrates that a learning episode in one iteration taking longer than the equivalent episode in another iteration does not imply that it was implemented either more or less effectively – the subject matter may have been covered more broadly or deeply.

T01_2006S2	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	11	31	0	1	0	17	0	2	62
Activity	0	1	0	0	0	0	0	0	1
Technology	0	0	0	0	0	0	0	0	0
Activity-Content	0	0	0	0	0	0	0	0	0
Activity-Technology	3	2	0	0	0	1	0	0	6
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	0	0	0	0	0	5	0	1	6
Unrelated/Unclassifiable	0	1	0	0	0	0	0	0	1
Totals	14	35	0	1	0	23	0	3	76

Table 43 – Topic 1 Iteration 3 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T01_2006S2	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	0	4	1	0	9	5	1	0	20
Activity	0	0	0	0	0	0	0	0	0
Technology	0	0	1	0	0	0	0	0	1
Activity-Content	0	0	0	0	0	0	0	0	0
Activity-Technology	0	0	0	0	2	0	0	0	2
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	0	0	0	0	2	1	0	0	3
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	0
Totals	0	4	2	0	13	6	1	0	26

Table 44 – Topic 1 Iteration 3 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Task 2 – "Distinguish Program Features" (from Topic 2)

Learning Task Analyzed: Identification (Declarative)

Question:
(From Horstmann Lab Exercise L1 Q10-14)
Refer to the following code. List all occurrences of the following:

Classes
Objects
Fields
Methods
Parameters
Local variables

```
public class PersonTest
{
    public static void main(String[] args)
    {
        Person p1 = new Person("Jim", 20);
        Person p2 = new Person("Candy", 60);
        System.out.println(p1.getName() + " is " + p1.getMonthsOld() + " months old.");
        System.out.println(p2.getName() + " is " + p2.getMonthsOld() + " months old.");
    }
}
```

```
public class Person
{
    private String name;
    private int age;
    private String company;

    public Person(String aName, int anAge)
    {
        name = aName;
        age = anAge;
        company = "None assigned";
    }

    public void setCompany(String aCompany)
    {company = aCompany;}

    public String getCompany()
    {return company;}

    public int getMonthsOld()
    {
        int months;
        months = age * 12;
        return months;
    }

    public String getName()
    {return name;}
}
```

Approaches:
In Iteration 1 a standard teacher-led question-response approach is adopted. In Iteration 2 and Iteration 3 students are required to identify programming constructs by collaborating in groups. This question tests declarative knowledge – the capacity for students to identify and classify different types of variables.

Learning Episode 4 (Topic 2 – Iteration 1)

Activity Design: Teacher-Led Question-Response
Interface Design: Presentational
Number of students: 8
Duration: 7.25 minutes

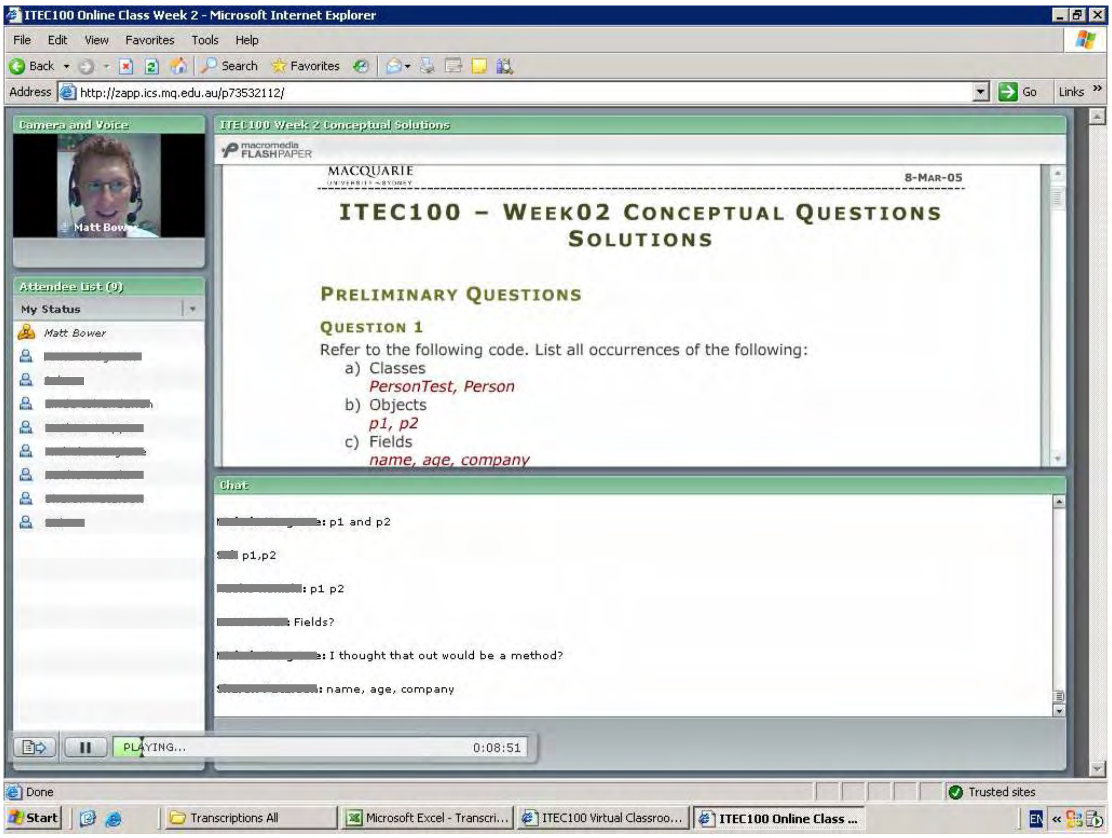


Figure 134 – Interface for episode in Topic 2 Iteration 1

Summary of episode:
In this sequence the teacher broadcasted a document containing the questions and revealed the solutions in retrospect (once the students have provided their suggestions for answers, see Figure 134). However, the teacher was unaware that in some cases the students may be able to see the solutions for the part of the question being addressed because the size of the document sharing pod depends on the size of the user's screen (meaning the bottom part of the document containing the solution may inadvertently be revealed).

The teacher asked students for their answers and they were able to respond at the same time as one another with short textual responses in the text-chat pod. The learning design allowed the content to be covered efficiently, with the entire exercise only taking 7.25 minutes. The eight students in the class made 35 text-chat contributions (Table 33), with all students making at least one contribution. The text-chat modality is suited to the declarative nature of the task in so far as students only need to evidence a unistructural level of understanding (individual items of non-related knowledge).

As well as the 68 audio sentences, the teacher also contributed six entries to the text-chat pod (ref. Table 32). These text-chat entries were used to emphasize the part of the question being addressed, and provide a marker in the text-chat discourse to delineate the separate sections. For instance, the teacher may have typed "Fields?" to reinforce that students should now focus on identifying the fields in the program. Supplementing audio commentary with text-chat is an example of a web-conferencing techno-pedagogical strategy.

A substantial component of the teacher's discourse related to coordinating the episode as compared to the Topic 1 learning episodes, with a combined total of 20 Activity, Activity-Content and Activity-Technology statements (ref. Table 45). These related to setting up and moving students through the learning activity, asking whether they had any questions, and suggesting how they contributed their ideas to the web-conferencing system (for instance, using copy and paste from their solutions to the text-chat pod). This appears to have allowed students to focus on the content of the task at hand with almost all of the students' contributions being curriculum matter responses to questions (33 Content Statement Response to Questions out of 36 textual discourse contributions, ref. Table 46).

T02_2005S2	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	**Totals**
Content	16	15	0	2	2	15	0	0	**50**
Activity	0	10	0	0	0	1	0	0	**11**
Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content	3	1	0	0	0	2	0	0	**6**
Activity-Technology	0	1	0	0	0	2	0	0	**3**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	1	0	0	0	3	0	0	**4**
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	**0**
Totals	**19**	**28**	**0**	**2**	**2**	**23**	**0**	**0**	**74**

Table 45 – Topic 2 Iteration 1 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T02_2005S2	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	**Totals**
Content	0	1	0	1	33	0	0	0	**35**
Activity	0	0	0	0	0	0	0	0	**0**
Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content	0	0	0	0	0	0	0	0	**0**
Activity-Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	0	0	0	0	0	0	0	**0**
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	**0**
Totals	**0**	**1**	**0**	**1**	**33**	**0**	**0**	**0**	**35**

Table 46 – Topic 2 Iteration 1 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Learning Episode 5 (Topic 2 – Iteration 2)

Activity Design: Group-work Tutorial Answer
Interface Design: Collaborative
Number of students: 8
Duration: 27.25 minutes

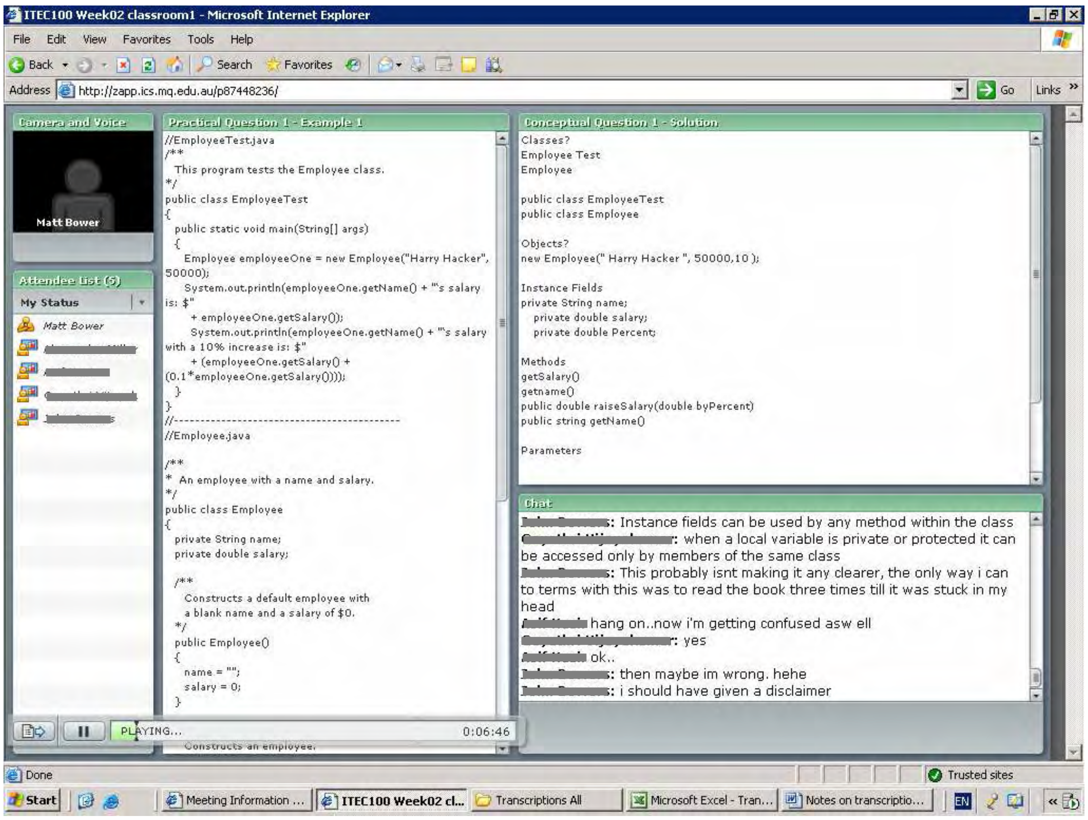


Figure 135 – Interface for episode in Topic 2 Iteration 2

Summary of episode:
In Iteration 2 of this learning task students were split into two group-work rooms from the main room (the first group-work room is shown in Figure 135 above). Rather than using the default room layout, the rooms were redesigned to meet the collaborative needs of the activity, with the program displayed in the left hand note-pod and a communal answer space provided using a note-pod in the top right corner of the room.

Textual discourse in the note-pod was observed to hold inherently different properties to textual discourse in the text-chat pod or through audio because it could be edited, deleted or moved. From Table 33 it can be seen that students made 39 textual discourse contributions to the note-pod (i.e., providing answers to questions) but also performed 6 non-textual actions (such as deleting incorrect answers).

This collaborative learning design resulted in a far greater number of student text-chat contributions during the episode than in the question-response learning design of Topic 2

Iteration 1 (182 versus 35, ref. Table 33). Not only did the students have their own space to communicate, but by virtue of splitting the seven students into two group-work rooms there was more space for each individual to contribute.

The use of this group-work design changed the role of the teacher. Firstly, a large number of teacher Activity and Activity-Technology statements were required to explain and coordinate this learning design (20 and 11 respectively, ref. Table 47); students required instructions on how the learning activity was to run and how they needed to work with the technology to complete the task. The design allowed the teacher to relinquish leadership of Content discussions, asking only one Independent Content Question as opposed to sixteen in Iteration 1 of this task (ref. Table 47, Table 45 respectively). As well, the use of group-work required the teacher to employ new lesson management strategies. This involved toggling browser windows between rooms, and being more conscious of the channels of communication being used in order to accurately direct discourse (for instance, using text-chat to make an unobtrusive comment to a particular group as opposed to using audio broadcast from the main room to a broadcast a directive to both groups).

The teacher also utilized more advanced technological competencies in this learning episode than in Iteration 1 by spontaneously redesigning the interface in the main room to contain two note-pods (one for each group's solutions) in order to facilitate comparison and contrast. It should also be pointed out that this learning episode was hindered by the teacher's lack of understanding of an aspect of the web-conferencing environment – the note-pod containing the program code was inadvertently changed to be the wrong program during the design stage because the teacher was unaware that note-pod contents between layouts were linked to one another. This meant that when the teacher changed the program code in another layout for another activity it changed the code for this activity.

In this learning episode students took a much more independent role with relation to the learning material being addressed as compared to Iteration 1. They posed 9 independent content related questions and made 46 independent content related statements (ref. Table 48). There was a large amount of discourse related to coordinating activity between students (47 sentences, ref. Table 48) as students needed to assign roles, decide when to move on, and determine who would perform different tasks. Interestingly, only 4% of student textual discourse (9 out of 221 contributions) related to the technology (Technology, or Activity-Technology), even though this was the first time that they had collaborated in this way. This could be attributed to students' familiarity with communicating using textual modalities.

Note that there are two channels for written textual discourse in this learning activity – the text-chat pod and the note-pod for the solution. Because a student can only type in one text region at a time an inefficiency is introduced as compared to being able to collaborate via audio and write solutions in the note-pod (which is the design utilized in Topic 2 Iteration 3). This resulted in split-attention (Ayres & Sweller, 2005). Another notable aspect of this episode is that all textual discourse contributions to the note-pod were content based. The note-pod is a solution space, and students automatically make any Activity or Technology related textual discourse contributions in the text-chat pod. In this way providing an explicit solution space acts as a filter, allowing content based contributions to be grouped without interference from other discourse (allowing for more effective cognitive processing due to less extraneous cognitive load).

While the teacher made a few less content related contributions in Iteration 2 of this learning activity as opposed to Iteration 1 (43 as opposed to 50, ref. Table 47 and Table 45 respectively) the students made far more Content contributions (138 as opposed to 35, ref. Table 48 and Table 46 respectively). As such it is not surprising that this learning episode took much longer than in Iteration 1 (27.5 minutes as opposed to 7.25 minutes). Note that student content related contributions per minute is slightly greater under the student-centred activity design as compared to the teacher-led design (5.0 contributions per minute as opposed to 4.8 contributions per minute), meaning that although they were managing the overhead of coordinating activity they were still contributing more Content discussions for the same amount of people.

T02_2006S1	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	1	26	0	4	4	8	0	0	**43**
Activity	2	20	0	0	2	3	0	0	**27**
Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content	1	0	0	0	3	1	0	0	**5**
Activity-Technology	1	11	0	0	0	0	0	0	**12**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	3	0	0	0	1	0	0	**4**
Unrelated/Unclassifiable	0	1	0	0	2	1	0	0	**4**
Totals	5	61	0	4	11	14	0	0	**95**

Table 47 – Topic 2 Iteration 2 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T02_2006S1	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	9	46	0	3	33	47	0	0	**138**
Activity	9	12	0	1	9	16	0	0	**47**
Technology	1	0	0	0	0	0	0	0	**1**
Activity-Content	5	1	1	2	2	2	0	0	**13**
Activity-Technology	0	1	0	0	7	0	0	0	**8**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	3	0	0	0	2	0	1	**6**
Unrelated/Unclassifiable	0	8	0	0	0	0	0	0	**8**
Totals	**24**	**71**	**1**	**6**	**51**	**67**	**0**	**1**	**221**

Table 48 – Topic 2 Iteration 2 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Learning Episode 6 (Topic 2 – Iteration 3)

Activity Design: Group-work Tutorial Answer
Interface Design: Collaborative
Number of students: 3
Duration: 27.5 minutes

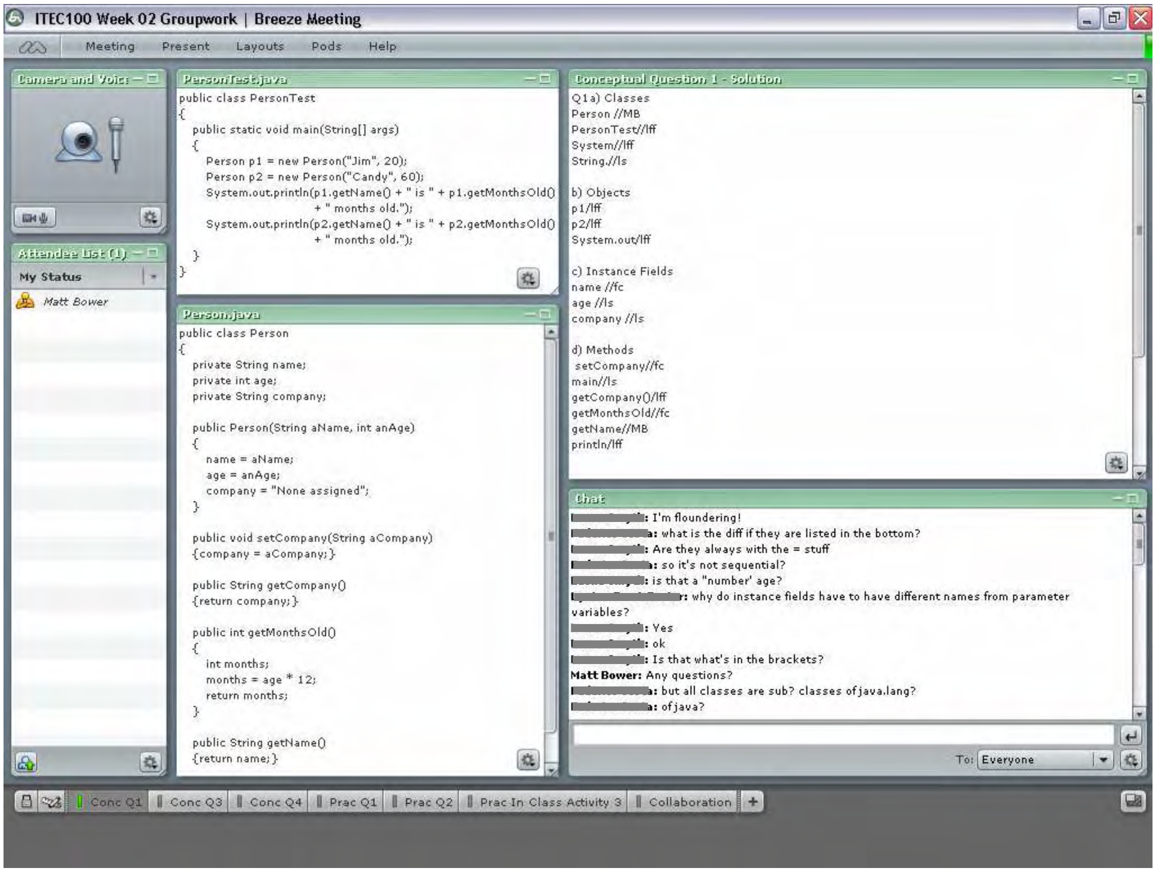


Figure 136 – Interface for episode in Topic 2 Iteration 3

Summary of episode:
In this Iteration students attempted the same task using the same interface design as in Iteration 2, except this time they were using audio and the teacher took a more active role in guiding their collaborative efforts. Using audio allowed students to contribute to the solution space (note-pod) at the same time as they were collaborating about the task, leveraging the Modality principle (Low & Sweller, 2005) and upholding the technology design principle of having an intuitive and transparent collaborative interface.

Students make 29 audio sentence contributions and 8 text-chat pod contributions (ref. Table 33). The text-chat contributions appear to be used by students to post collaborations in a manner that does not interfere with the flow of audio conversation. For instance, three of the student text-chat posts were Independent Questions made while the teacher was talking.

The increased presence of the teacher in Topic 2 Iteration 3 as compared to Iteration 2 is evident in several measures. For instance, the teacher made 131 Content contributions in Iteration 3 as opposed to 43 in Iteration 2 (ref. Table 49, Table 47 respectively). As well, in Iteration 3 the teacher made 61 activity related textual discourse contributions (Activity, Activity-Content, Activity-Technology, Activity-Content-Technology, ref. Table 49) as compared to 44 in Iteration 2 (ref. Table 47). That is to say the teacher is more involved in guiding the discussion of curriculum and the coordination of activity.

At the same time the number of student contributions in Iteration 3 was far less than in Iteration 2. Students made 53 Content based textual discourse contributions in Iteration three as opposed to 138 in Iteration 2 (ref. Table 50, Table 48 respectively). As well, students made only 10 activity related discursive contributions as opposed to 68 in Iteration 2. This indicates that while the teacher was more involved in content and activity discussions, students are less involved. Note that even when the amount of Content and activity related contributions per person are calculated, the amounts are still less in Iteration 3 (for approximately the same duration of learning episode).

Even though students used audio in Iteration 3, the amount of textual discourse per person that occurred outside the note-pod did not increase as compared to Iteration 2. For Iteration 3 the average number of contributions per person outside the note-pod was 12.3 as opposed to 22.8 in Iteration 2. This 46% decrease between the two learning episodes could be related to the more than 240% increase in teacher textual discourse contributions outside the note-pods.

Note that the time taken for the two student-centred approaches adopted in Iteration 2 and Iteration 3 was similar – approximately 27 minutes. This is far greater than the 10.5 minutes taken using the teacher-led question-response approach of Iteration 1.

T02_2006S2	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	**Totals**
Content	16	55	2	0	21	36	1	0	**131**
Activity	1	5	0	0	3	4	1	6	**20**
Technology	0	2	0	0	0	0	0	0	**2**
Activity-Content	6	6	1	0	3	5	0	0	**21**
Activity-Technology	1	13	1	0	2	0	0	1	**18**
Activity-Content-Tech.	0	1	0	0	1	0	0	0	**2**
Content-Technology	1	0	0	0	0	0	0	0	**1**
Task sentiments/attitudes	1	7	0	0	4	10	0	1	**23**
Unrelated/Unclassifiable	0	4	0	0	0	0	0	1	**5**
Totals	**26**	**93**	**4**	**0**	**34**	**55**	**2**	**9**	**223**

Table 49 – Topic 2 Iteration 3 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T02_2006S2	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	**Totals**
Content	8	3	3	1	37	1	0	0	**53**
Activity	0	2	2	0	0	2	0	0	**6**
Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content	0	0	0	0	0	0	0	0	**0**
Activity-Technology	1	1	0	0	2	0	0	0	**4**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	1	0	0	0	1	0	0	**2**
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	**0**
Totals	**9**	**7**	**5**	**1**	**39**	**4**	**0**	**0**	**65**

Table 50 – Topic 2 Iteration 3 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Task 3 – "Write SoftDrinkCan Program" (Topic 3)

Learning Task Analyzed: Meet a design specification (Procedural)

Question:
(From Horstmann, 2003 Exercise P2.15)
Implement a class SoftDrink with methods getSurfaceArea() and getVolume(). In the constructor supply the height and radius of the can.

[Note that students had just completed an exercise to write a Square class (with methods to return the perimeter and area) which they were able to use as a guide for this activity.]

Approaches:
In Iteration 1 a teacher-led programming approach was adopted. The teacher shared their screen and prompted students for suggestions about what to do next. Students responded using text-chat.

In Iteration 2 a student-centred (group programming) approach was adopted, where students were separated out into two group-work rooms and one of the students shared their screen. The other students in the group then made suggestions via text-chat about how to solve the programming problem.

In Iteration 3 a teacher-led programming approach similar to Iteration 1 was adopted, except that students used audio. This approach was used due to time restrictions in the lesson.

Learning Episode 7 (Topic 3 – Iteration 1)

Activity Design: Teacher-Led Programming
Interface Design: Presentational
Number of students: 8
Duration: 18.5 minutes

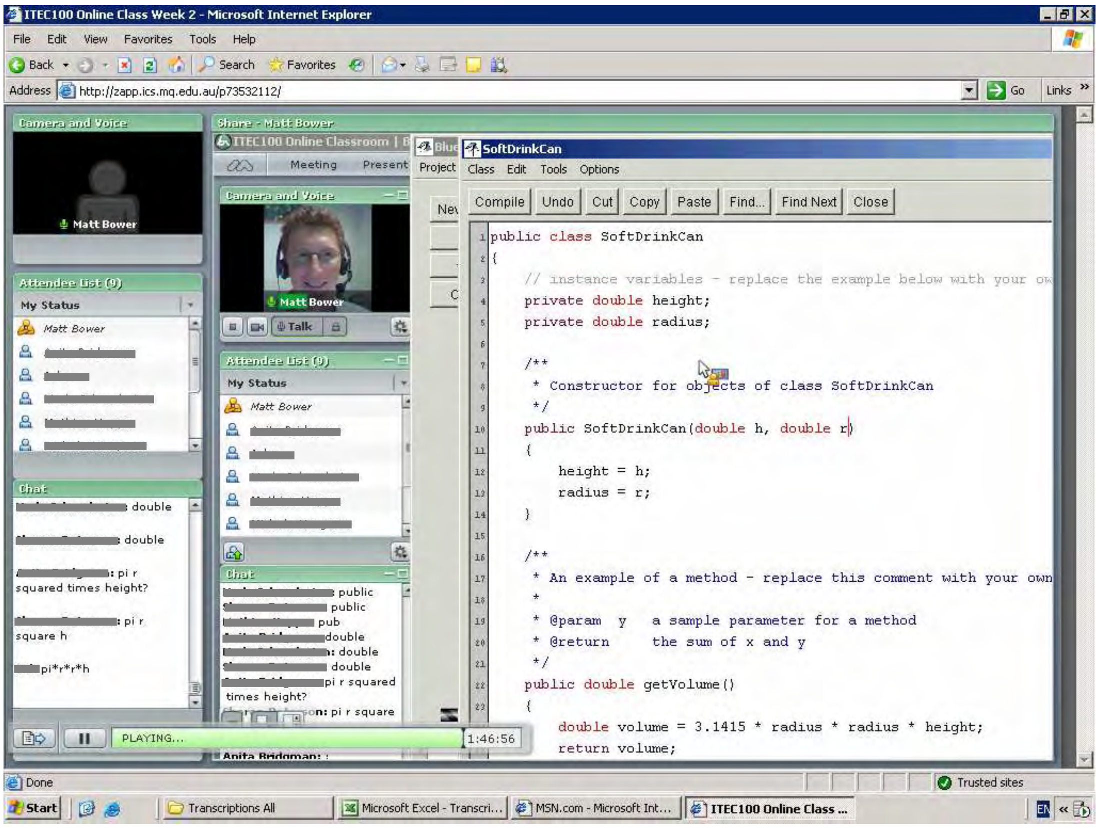


Figure 137 – Interface for episode in Topic 3 Iteration 1

Summary of episode:
The default "sharing" interface was used, and once again the teacher rebroadcasts the text-chat pod as the only way he knows to receive student discourse while screen-sharing (see Figure 137). The teacher-led programming learning design allowed the processes and thinking behind writing a program to be modelled by the teacher. Students could see all the actions required to write the program (35 distinct actions recorded in this episode, ref. Table 32), and by explicating underlying thought processes the teacher was able to offer a form of cognitive apprenticeship (Collins, Brown, & Holum, 1991). Student engagement was maintained by requiring their input and suggestions about the next steps to solve the problem.

Teacher textual discourse consisted entirely of 157 audio comments (ref. Table 32). Note that having an auditory channel (Voice over IP) explaining activity occurring in a visual channel (screen-share of desktop) took advantage of the Modality principle (Low & Sweller, 2005). A substantial amount of the teacher discourse related to explaining the way in which students were supposed to engage with the learning activity (14 Activity Independent Statements, and 5 Activity-Content Independent Statements, ref. Table 51). There is a large component of the episode that was instructive; during the course of the learning episode the teacher made 118 Content contributions, of which 48 were Independent Statements (ref. Table 51).

However the learning design supported the teacher in adopting an interactive approach. For instance the teacher made 25 Content Statement Responses to Statements. As well, the teacher provided 14 Statement Response to Question comments in response to a student question regarding the meaning of the "public static void main" method signature.

Students delivered all of their textual discourse through the text-chat pod (44 comments, ref. Table 33). Of the 44 textual discourse contributions made by students, 43 were Content contributions (ref. Table 52). That is to say the learning design allowed students to focus on the curriculum matter without needing to attend to activity or technology related matters. However, 37 of these were Statement Responses to Questions (ref. Table 52). Students were responding to specific teacher questions about what to do next in a "Socratic" sense (Laurillard, 2002, p. 87) rather than controlling the problem-solving process.

T03_2005S2	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	**Totals**
Content	24	48	1	0	14	25	0	6	**118**
Activity	0	14	0	0	0	0	0	0	**14**
Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content	1	5	0	0	1	0	0	1	**8**
Activity-Technology	0	4	0	0	0	0	0	0	**4**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	2	0	0	2	5	0	0	**9**
Unrelated/Unclassifiable	0	3	0	0	0	1	0	0	**4**
Totals	**25**	**76**	**1**	**0**	**17**	**31**	**0**	**7**	**157**

Table 51 – Topic 3 Iteration 1 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T03_2005S2	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	1	1	2	1	37	1	0	0	**43**
Activity	0	0	0	0	0	0	0	0	**0**
Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content	0	0	0	0	0	0	0	0	**0**
Activity-Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	0	0	0	0	1	0	0	**1**
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	**0**
Totals	**1**	**1**	**2**	**1**	**37**	**2**	**0**	**0**	**44**

Table 52 – Topic 3 Iteration 1 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Learning Episode 8 (Topic 3 – Iteration 2)

Activity Design: Group Programming
Interface Design: Collaborative
Number of students: 9
Duration: 19 minutes

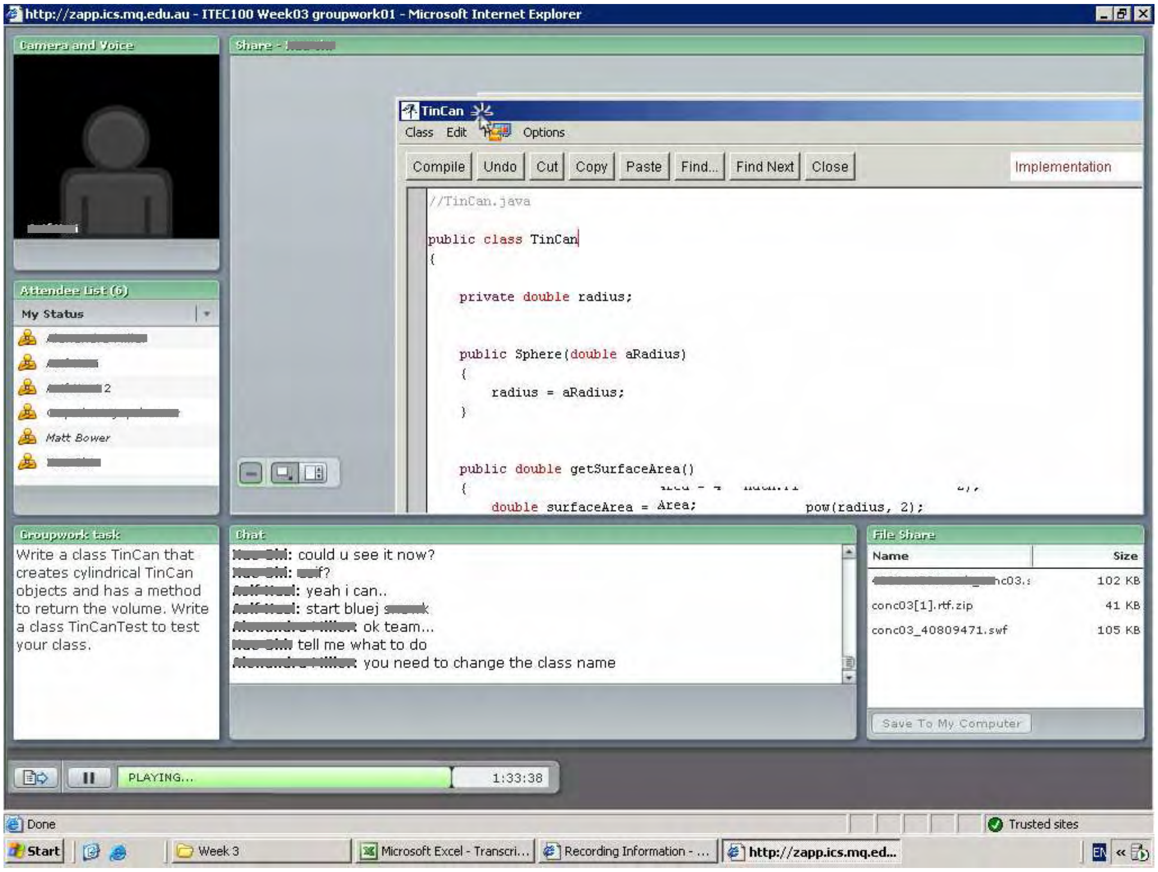


Figure 138 – Interface for episode in Topic 3 Iteration 2

Summary of episode:

For this episode group-work room interfaces were designed to include a note-pod containing the question, a large horizontal text-chat area, a central screen-share area and a file-share pod to facilitate the exchange of programming code if necessary (see Figure 138). Students were granted higher access permissions which allowed them to adjust or contribute to any aspect of the web-conferencing environment. A student from each group was selected by the teacher to share their screen.

Note that approximately the same number of teacher textual discourse comments were recorded in Iteration 2 of this learning activity as Iteration 1 (139 as opposed to 157, ref. Table 53 and Table 51 respectively) and that the episode durations were almost identical (19 and 18.5 minutes, respectively). The teacher provided links to the two group-work rooms from the text-chat pod in the main room, with all other 137 textual discourse contributions being made via audio from the main room (ref. Table 32). The advantage of using audio from the main room was that even when the main room browser was not the focus of students' screen they could still hear the audio being broadcast by the teacher. That meant students could communicate via text-chat and the teacher's audio comments need not interrupt the flow of their discourse.

This learning design allowed students to assume a much more active roll than Iteration 1. A total of 74 student contributed Modelling Programming actions were recorded, as compared to none in Iteration 1 where the teacher was controlling the problem solving process (Table 33). As well, students made 145 textual discourse contributions in this Iteration, as opposed to 44 in Iteration 1 (ref. Table 33). Note that there was only one more student in Iteration 2 than Iteration 1, meaning a substantially greater number of textual discourse contributions per person per minute in the student-centred activity design of Iteration 2.

A major problem with the implementation of this task was that the student responsible for broadcasting their screen in each group was not familiar with how the technology operated. Both students were unaware that if they minimized their group-work room browser window while broadcasting their screen student text-chat messages would be momentarily displayed small popup windows. Because they were unaware of this they took compensatory action, as described below.

In Group 1 the person broadcasting their screen to show the IDE repeatedly selected the group-work room browser window to bring it to focus (so they could see student text-chat contributions) and then reselected the IDE (which happened 12 times, ref. Table 33). This meant that screen broadcast received by the other students in the group contained several disconcerting shifts of focus from the IDE to the web-conferencing environment. It is interesting to note that after an initial period of Activity-Technology statements the dialogue settles to a string of Content collaborations. The cognition appears to be shared amongst the group in a manner similar to a person speaking to themselves about a concept; no activity or technology based discourse required.

In Group 2 the student broadcasting their screen circumvented the need to bring the web-conferencing environment to focus in order to receive text-chat by typing discursive comments in the source code file with which they were working (occurring 9 times, ref. Table 33). Both of the deliveries offered by students were less than ideal, and could have been avoided if either a) students had been using audio, or b) the students had been given adequate prior instruction on how to appropriately use the technology in this learning activity. Student discourse during the activity indicated that at times their comprehension suffered as a result of the communication approaches being adopted. The collaborative problems students were experiencing led to a large number of Activity-Technology contributions by the teacher (39 in total, ref. Table 53) in an attempt to spontaneously rectify the situation.

The data demonstrates how role of the teacher shifted from one of knowledge bearer in the teacher-led activity design of Iteration 1 to one of activity facilitator under this student-centred activity design of Iteration 2, with 42 Activity sentences as opposed to 32 Content sentences in this second iteration (ref. Table 53). A greater proportion of teacher discourse was expended explaining the task and encouraging student contributions. The shift away from being the content provider allowed the teacher to offer more feedback to students during the task, with 25 teacher responses to student actions being recorded (ref. Table 53).

On the other hand students made a far greater number of Content contributions in Iteration 2 than in Iteration 1 of this task (74 as compared to 43, ref. Table 54, Table 52 respectively). These content contributions included 5 Content Independent Questions, and 44 Content Responses (to either Questions, Statements or Actions, ref. Table 54). Thus in the Iteration 2 learning design students were interacting more with one another than in the equivalent Iteration 1 design.

The student-centred activity design allowed students to develop a shared understanding by means of negotiation. In the teacher-led activity design implemented in the previous iteration the class need only possess a multi-structural understanding (because the teacher could choose to sequence and complete those aspects of the solution that had not been suggested by students). Because the group was responsible for the entire solution in this iteration it was possible to assess that the group possessed a relational understanding of the content being addressed. The screen-share modality supports effective sharing and assessment of student understanding by authentically representing their (procedural) knowledge rather than just the final answer (product).

There were a large number of Activity (29, ref. Table 54) and Activity-Content (25, ref. Table 54) contributions as students coordinated what should be done and by whom. The Activity comments tend to appear early in the group-work room discourse as students attempted to establish presence, rolls and strategies. The Activity-Content contributions acted as a transition from the Activity discourse to the Content discourse, where students were determining what people should be doing in order to solve the problem at hand, for instance what others should do with relation to the problem solving process, such as “you need to change the class name”. Note that by the end of the learning episode the textual discourse generally makes no reference to who is to make each contribution, because the collaborative patterns have already been established. For instance, later on in the episode a student may simply post the text-chat comment “then public double getVolume” which makes no explicit reference to what needs to be done (e.g. make a change to the program code) or who needs to do it – these are assumed.

Chi-Square tests for differences between textual discourse profiles in Iteration 1 and Iteration 2 were performed, all of which returned significant results. These included:

- The subject of teacher textual discourse in Iteration 1 was significantly different to that of Iteration 2 ($\chi^2 = 91.6$, $p < 0.0001$, d.f. = 4, ref. Statistical Test 3). In the teacher-led approach of Iteration 1 there was a significantly greater proportion of teacher Content contributions, a significantly lower proportion of teacher Activity contributions, and a significantly lower proportion of teacher Activity-Technology contributions (ref. Statistical Test 3). This supports the argument that the teacher-led approach allowed students to focus more on Content and less on coordinating activity between students.

- The nature of teacher textual discourse interactions in Iteration 1 was significantly different to that in Iteration 2 ($\chi^2 = 29.2$, $p = 0.00002$, d.f. = 5, ref. Statistical Test 4). The student-centred approach of Iteration 2 contained a significantly greater proportion of teacher Statement Responses to Actions, mostly as a result of the teacher providing feedback to students about their approaches (ref. Statistical Test 4). As well, the teacher asks a significantly greater proportion of Independent Questions in Iteration 1 as they led the conversation (ref. Statistical Test 4).
- The subject of student textual discourse in Iteration 1 was significantly different to that of Iteration 2 ($\chi^2 = 35.2$, $p < 0.0001$, d.f. = 4, ref. Statistical Test 5). In Iteration 1 there was a significantly greater proportion of student Content contributions and a significantly lower proportion of Activity and Activity-Content contributions (ref. Statistical Test 5).
- The nature of student textual discourse interactions in Iteration 1 was significantly different to that of Iteration 2 ($\chi^2 = 55.3$, $p < 0.0001$, d.f. = 5, ref. Statistical Test 6) In particular, there was a significantly lower proportion of student Independent Statements in Iteration 1 than Iteration 2 and significantly more Statement Responses to Questions (ref. Statistical Test 6).

To summarize the results contained above, the teacher-led approach allowed the teacher and students to focus on Content as opposed to Activity, Activity-Content and Activity-Technology textual discourse. However the student-centred approach allowed students to collaborate more, students to make more independent and less responsive contributions, and provided the opportunity for the teacher to provide more feedback.

T03_2006S1	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	**Totals**
Content	7	13	0	0	1	6	0	5	**32**
Activity	1	31	0	0	2	5	0	3	**42**
Technology	0	2	0	0	0	0	0	2	**4**
Activity-Content	0	6	0	0	1	0	0	2	**9**
Activity-Technology	0	22	0	0	1	3	0	13	**39**
Activity-Content-Tech.	0	1	0	0	0	0	0	0	**1**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	8	0	0	0	4	0	0	**12**
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	**0**
Totals	**8**	**83**	**0**	**0**	**5**	**18**	**0**	**25**	**139**

Table 53 – Topic 3 Iteration 2 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T03_2006S1	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	5	25	1	0	26	9	2	6	74
Activity	6	13	0	3	3	3	0	1	29
Technology	0	0	0	0	0	1	0	5	6
Activity-Content	8	8	0	0	7	1	0	1	25
Activity-Technology	2	2	0	2	2	0	0	2	10
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	0	3	0	0	0	3	0	0	6
Unrelated/Unclassifiable	0	3	0	0	0	1	0	0	4
Totals	21	54	1	5	38	18	2	15	154

Table 54 – Topic 3 Iteration 2 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Learning Episode 9 (Topic 3 – Iteration 3)

Activity Design: Teacher-Led Programming
Interface Design: Presentational
Number of students: 3
Duration: 17 minutes

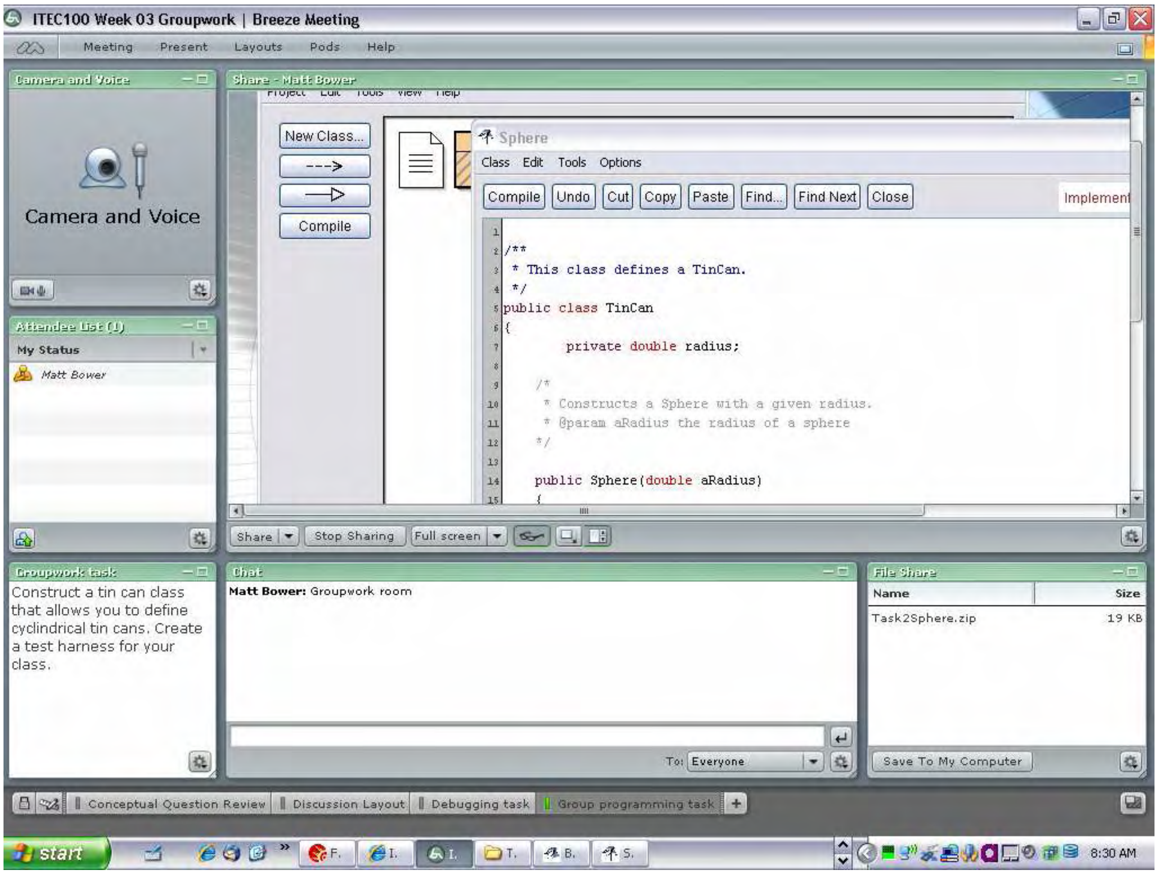


Figure 139 – Interface for episode in Topic 3 Iteration 3

Summary of episode:
This Iteration utilized same user interface as Iteration 2, however the teacher took the role of the screen-sharer implying a teacher-led programming activity design. As well, students used audio to make textual discourse contributions rather than text-chat.

The more involved teacher role in the learning episode is illustrated by the large number of textual discourse contributions made by the teacher through the audio channel (178, ref. Table 32). The number of student textual discourse contributions in this learning episode is 48 (made using audio), which is far less than the number made in Iteration 2 (145), but commensurate with the 44 made when this teacher-led programming design was used in Iteration 1 (ref. Table 33). In this circumstance it appears that the activity design (teacher-led programming versus student-centred programming) has a far greater impact on the level of student contribution than the mode of contribution (text-chat versus audio).

Under this teacher-led learning design the teacher returns to being the source of all actions throughout the learning episode, with 48 Modelling Programming contributions being recorded (ref. Table 32). It should also be noted that during this Iteration a user interface issue spontaneously arises as to whether or not students can watch the desktop broadcast full-screen mode without affecting the teacher's interface. This dynamic design experimentation results in the teacher making six "Adjustment to the Virtual Classroom Interface" actions as well as 13 Activity-Technology audio based textual discourse contributions.

Of the 178 textual discursive contributions made by the teacher, 126 were Content sentences (ref. Table 55). There were also 16 Activity and 8 Activity-Content teacher contributions (ref. Table 55) that relate to managing the learning episode. In this implementation of the activity the teacher asks more Independent Question sentences relating to Content than there are student responses to questions, which is a result of allowing questions to go unanswered by students (i.e. providing self-explanations), and sometimes rephrasing a question to re-emphasize it to students. The teacher's approach to leading the discourse influence the type of collaboration that transpires.

Nine of the 48 textually discursive student contributions were Activity-Technology sentences (ref. Table 56) which related to watching broadcasts in full-screen mode. Once again, the Activity-Technology statements occurred at the beginning of the episode, but soon the dialogue settled to a Content based discussion. As in Iteration 1, most of the Content contributions made by students were Statement Responses to Questions, most of which had been posed by the teacher (16 out of 31, ref. Table 56). There were also nine student contributed Question Responses to Questions in this episode. All of these were contributed by one student who adopted an unsure style of responding to questions. For instance, in response to the question "what [methods] do you want?" the student replied "Should we just have getVolume?".

When Chi-square tests were used to compare the textual discourse for the teacher-led approach of Iteration 1 to the teacher-led approach of Iteration 3, the following results were obtained:

- there were no significant difference in the subject of teacher textual discourse between Iteration 1 and Iteration 3 ($\chi^2 = 4.00$, $p = 0.4057$, d.f. = 4, ref. Statistical Test 7)
- there were no significant difference in the interactive nature of teacher textual discourse between Iteration 1 and Iteration 3 ($\chi^2 = 7.88$, $p = 0.1628$, d.f. = 5, ref. Statistical Test 8).
- there was a significant difference in the subject of student textual discourse between Iteration 1 and Iteration 3 ($\chi^2 = 16.6$, $p = 0.0023$, d.f. = 4, ref. Statistical Test 9). This statistic was unduly affected by the students' attempt to use full-screen mode mid-episode in Iteration 3, resulting in an unusually high proportion of Activity-Technology contributions.

- there were no significant difference in the interactive nature of student textual discourse between Iteration 1 and Iteration 3 ($\chi^2 = 9.38$, $p = 0.0950$, d.f. = 5, ref. Statistical Test 10).

However, when Chi-square tests were used to compare the textual discourse for the student-centred approach of Iteration 2 to the teacher-led approach of Iteration 3, all results were significant:

- there was a significant difference in the subject of teacher textual discourse between Iteration 2 and Iteration 3 ($\chi^2 = 77.1$, $p < 0.0001$, d.f. = 4, ref. Statistical Test 11). Specifically, there were a significantly greater proportion of teacher Content contributions in Iteration 3 and significantly less Activity and Activity-Technology contributions (ref. Statistical Test 11).
- there was a significant difference in the interactive nature of teacher textual discourse between Iteration 2 and Iteration 3 ($\chi^2 = 33.0$, $p < 0.0001$, d.f. = 5, ref. Statistical Test 12). In particular, there were a significantly greater proportion of teacher independent questions in Iteration 3 and less Statement responses to Actions (ref. Statistical Test 12).
- there was a significant difference in the subject of student textual discourse between Iteration 2 and Iteration 3 ($\chi^2 = 17.0$, $p = 0.0019$, d.f. = 4, ref. Statistical Test 13). This was not significantly attributable to any one type of subject discourse, however there were more Content and Activity-Technology contributions in Iteration 3 as compared to Iteration 2 (ref. Statistical Test 13).
- there was a significant difference in the interactive nature of student textual discourse between Iteration 2 and Iteration 3 ($\chi^2 = 36.2$, $p < 0.0001$, d.f. = 5, ref. Statistical Test 14). Iteration 3 contained a significantly lower proportion of student Independent Statements and a significantly higher proportion of student Statement Responses to Questions (ref. Statistical Test 14).

Thus Iteration 3 compares to Iteration 2 in much the same way as Iteration 1; the teacher-led approach of Iteration 3 allowed the teacher and students to focus on Content as opposed to activity based textual discourse, students made more responsive and less independent contributions. The similarity in discourse between Iteration 1 and Iteration 3 is particularly interesting to note in light of the differences in class size (eight versus three) and primary mode of student contribution (text-chat versus audio).

T03_2006S2	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	**Totals**
Content	20	70	0	3	9	21	0	3	**126**
Activity	3	11	0	0	0	2	0	0	**16**
Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content	2	4	0	1	1	0	0	0	**8**
Activity-Technology	3	6	1	1	0	1	0	1	**13**
Activity-Content-Tech.	1	0	0	0	0	0	0	0	**1**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	3	2	0	0	0	3	0	2	**10**
Unrelated/Unclassifiable	1	3	0	0	0	0	0	0	**4**
Totals	**33**	**96**	**1**	**5**	**10**	**27**	**0**	**6**	**178**

Table 55 – Topic 3 Iteration 3 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T03_2006S2	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	**Totals**
Content	2	0	9	0	16	3	0	1	**31**
Activity	0	0	0	0	2	0	0	0	**2**
Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content	1	0	0	0	1	0	0	0	**2**
Activity-Technology	0	2	1	0	5	0	0	1	**9**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	0	0	0	2	0	0	0	**2**
Unrelated/Unclassifiable	0	1	0	0	1	0	0	0	**2**
Totals	**3**	**3**	**10**	**0**	**27**	**3**	**0**	**2**	**48**

Table 56 – Topic 3 Iteration 3 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Task 4 – "Applet Comprehension Questions" (Topic 4)

Learning Task Analyzed: Comprehension (Conceptual)

Questions:

Explain the difference between an Application and an Applet (from Horstmann, 2003, Exercise R4.1).
What are the advantages of applications over applets? What are the advantages of applets over applications?
What security features do Applets have?

Approaches:
This task addresses conceptual knowledge regarding Applets.

In Iteration 1 a teacher-led question-response learning design was used to solicit student suggestions to the above questions. A presentational interface was used, with the intention to broadcast solutions after each question had been addressed.

In Iteration 2 students were split into two purpose designed group-work rooms and asked to form group answers to the above questions (i.e., a student-centred activity design). Text-chat was used as the primary mode of communication in one room and audio in the other. This was a unique trial of using student audio in Semester 1 of 2006 (Iteration 2).

In Iteration 3 the same interface was used as Iteration 2, except audio was used as the primary mode of discourse. The teacher adopted a more involved role in coordinating activity in the lesson than in Iteration 2, although the approach was still student-centred in so far as students were contributing the conceptual knowledge).

Learning Episode 10 (Topic 4 – Iteration 1)

Activity Design: Teacher-Led Question-Response
Interface Design: Presentational
Number of students: 9
Duration: 8.75 minutes

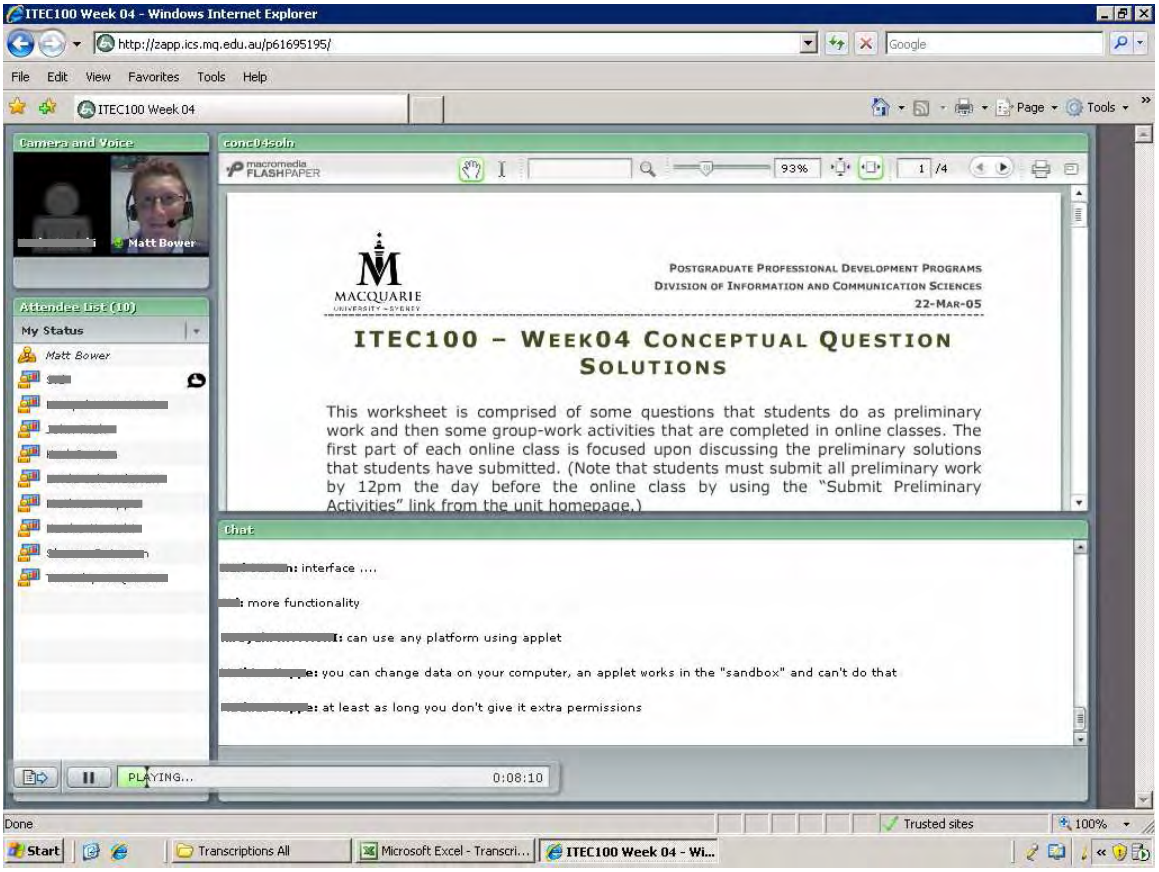


Figure 140 – Interface for episode in Topic 4 Iteration 1

Summary of episode:
A standard sharing interface was used to apply a teacher-led question-response learning design, with the text-chat pod stretched along the bottom of the window. The teacher made 73 textual discourse contributions using audio to implement the episode (ref. Table 32). Four text-chat contributions were also made (ref. Table 32) that served to re-emphasize the transition between questions, with posts such as "Advantages of Applications over Applets" indicating to students that they should be typing corresponding solutions in the text-chat pod.

The teacher challenged students to elaborate on the solutions they originally contribute, which is indicated by the four teacher Question Response to Statements (ref. Table 57). Also, the teacher often reiterates the comments of students, which is the reason for the large number of teacher Statement Responses to Statements (33, ref. Table 57). The teachers'

Activity-Content comments related to managing the learning episode with statements such as "the first question was explain the difference between an application and an applet" and asking students if they had any questions.

Of the 35 textual discourse comments made by the students, 34 were Content contributions and 29 were Statement Responses to Questions (ref. Table 58). The teacher's attempt to promote dialogue by asking questions did result in further discussion. However the approach causes students to assume an almost entirely responsive role, with only one Independent Statement and one student question posed during the episode (ref. Table 58).

The teacher performs a critical pedagogical error during this episode that is not detected until later in the lesson. During this episode the teacher intended to scroll down the solutions as they had been attempted. However, due to the fact that "synch" mode was not switched on, the presenter's scrolling did not affect the student view. As well, since students had been given presenter status, they could scroll through the document themselves, meaning they had access to the solutions (unbeknownst to the teacher). This may have affected the amount and type of student discourse.

T04_2005S2	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	**Totals**
Content	9	7	0	4	2	33	0	0	**55**
Activity	1	4	0	0	0	0	0	1	**6**
Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content	2	3	0	0	1	1	0	0	**7**
Activity-Technology	0	1	0	0	0	0	0	1	**2**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	1	0	0	0	1	0	0	**2**
Unrelated/Unclassifiable	0	5	0	0	0	0	0	0	**5**
Totals	**12**	**21**	**0**	**4**	**3**	**35**	**0**	**2**	**77**

Table 57 – Topic 4 Iteration 1 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T04_2005S2	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	0	1	0	1	29	3	0	0	34
Activity	0	0	0	0	0	0	0	0	0
Technology	0	0	0	0	0	0	0	0	0
Activity-Content	0	0	0	0	1	0	0	0	1
Activity-Technology	0	0	0	0	0	0	0	0	0
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	0	0	0	0	0	0	0	0	0
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	0
Totals	0	1	0	1	30	3	0	0	35

Table 58 – Topic 4 Iteration 1 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Learning Episode 11 (Topic 4 – Iteration 2)

Activity Design: Group-work Tutorial Answer
Interface Design: Collaborative
Number of students: 8
Duration: 17.25 minutes

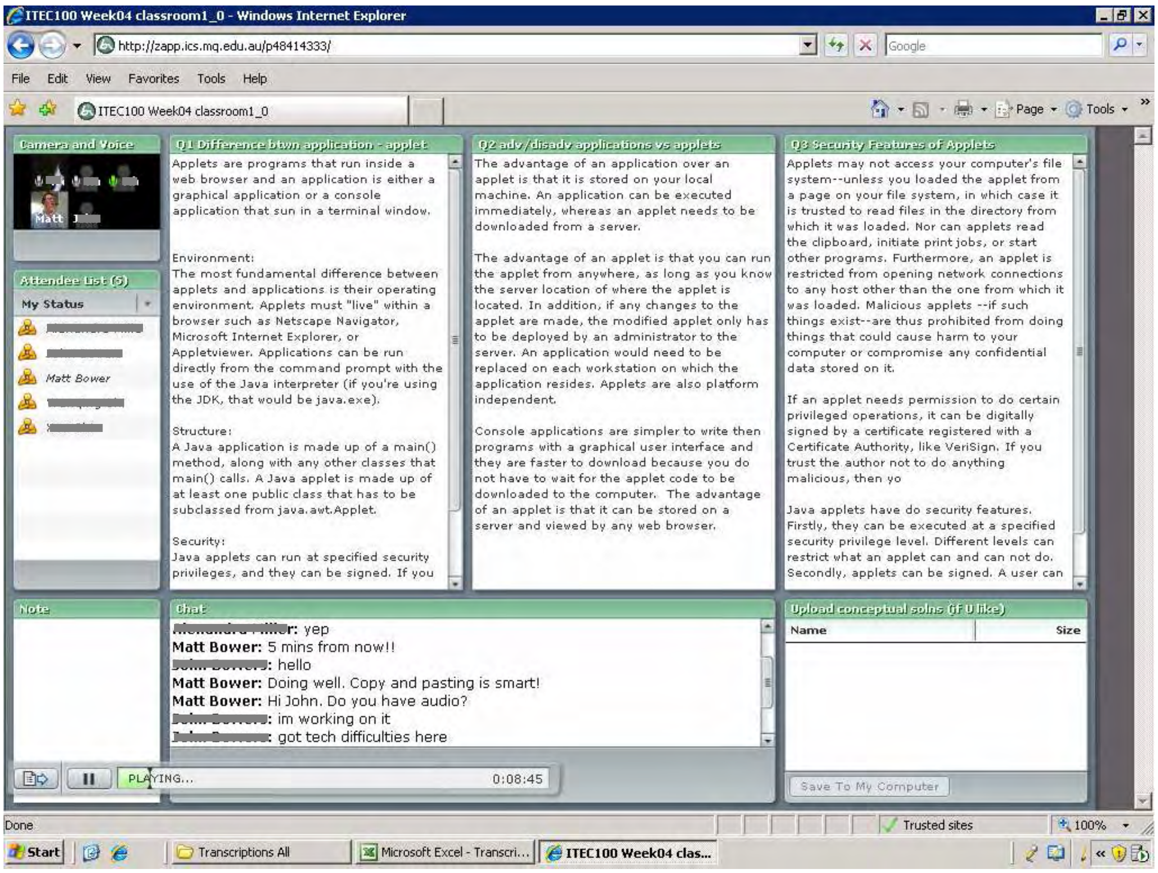


Figure 141 – Interface for episode in Topic 4 Iteration 2

Summary of episode:
In Iteration 2 of this Topic students were split into two purpose designed group-work rooms (one of which is illustrated in Figure 141) and asked to provide collaborative solutions to the three conceptual questions. A solution space for each of the three questions is provided by three separate note-pods. One of the groups used audio and the other did not, in order to trial the use of audio and gauge its utility. The students for the audio group were chosen on the basis of those who had pre-tested audio on their computer before the lesson.

The majority of the 59 teacher textual discourse contributions made during this learning episode were activity related (29 Activity, 3 Activity-Content, 15 Activity-Technology, ref. Table 59), indicating the coordination role that the teacher adopted. Of those, 49 were audio based textual discourse contributions and 10 were note-pod comments (ref. Table 32). All note-pod comments were related to coordinating activity, for instance reminding students in the group-work room of how much time they had left or asking if they had finished. Only two of the 59 textually discursive teacher contributions related to Content (ref. Table 59) indicating a true divulgence of responsibility for learning the material to the students.

Once again the note-pod acted as a filter, with the only type of textual discourse contributions being Content. This reduced extraneous cognitive load if a student wished to focus exclusively on the curriculum matter solution. The separate solution spaces also enabled a shared understanding to be formed, with editing and movement of information possible. Students could provide more structure to their solution allowing them to more easily demonstrate a relational understanding of the content.

Having the note-pods as a communal solution space allowed for more efficient student interactions by facilitating rapid copying and pasting of large textual contributions than would be possible in the text-chat pod (leveraging a spatial affordance of the note-pod tool). However one of the disadvantages of this note-pod approach to forming group solutions is that the identity of the contributor or editor was not recognizable. In some cases a "distributed process loss" (Neale, Carroll, & Rosson, 2004) was incurred as students tried to identify who had made a post. It should also be noted that the use of large amounts of content does not necessarily imply greater learning - the level of processing of that information is contingent on student approach (self imposed germane cognitive load) and potentially task specification and teacher encouragement.

Students made 231 textual discourse contributions in this 17.25 minute episode; 108 through audio, 54 through text-chat, and 69 through their solutions to the note-pod (ref. Table 33). Student contributions of solutions to the note-pods have been included as textual discourse because they involve the exchange of textual language based information about a particular concept or topic. This was a rate of 13.4 student textual discourse contributions per minute as opposed to 4.0 student textual discourse contributions per minute in Iteration 1. This indicates a much higher level of involvement in Iteration 2, considering there were more students in the Iteration 1 episode.

The two group-work rooms varied by their amount and type of contribution. In the audio group-work room students made 108 audio contributions, 28 note-pod contributions and 9 text-chat contributions. Of these 145 contributions 45 were Content contributions, 39 Activity contributions and 21 Activity-Technology contributions were made. Several of the Activity-Technology contributions were made via text-chat to help one student with their audio. A total of 33 contributions related to expressions of task sentiments or attitudes, or unrelated discussion. There was a greater proportion of personal expression in this group-room transcript than any other transcript in this corpus of data.

In the non-audio room students made 32 text-chat contributions and 41 note-pod contributions. Of these 47 were Content contributions and 22 were Activity contributions. There was only 3 Activity-Technology statements and no contributions related to expressions of task sentiments or attitudes, or unrelated discussion. These differences between the two rooms in the amount of social and expressive discourse could be related to the conversational media but could also be related to the characters in the group. Further research would be required to determine the true cause and effect.

Towards the end of the task students were asked to review the other group's solution and on this basis improve their own solution. This resulted in two Activity-Content statements by group one confirming the validity of their solution, and two statements being pasted from group-work room 1 into group-work room 2. As well as the small amount of Content related discourse manifest by this reflective component of the task, no students accepted the offer to ask questions relating to the task. The extra activity overhead of requiring transitions between rooms did not impact on the flow of the lesson – students needed no assistance with this process.

Note that the collaborative group-work approach adopted in this Iteration took 17.25 minutes as opposed to 8.75 minutes in Iteration 1. Students made a total of 218 textual discourse contributions under the collaborative learning design compared to only 35 under the Teacher-Led Question Response approach in the previous semester (ref. Table 33). The collaborative approach led to a greater range of student contributions – 29 of the 35 student textual discourse contributions in Iteration 1 were Content Statement Response to Questions (ref. Table 58) whereas in Iteration 2 there is a strong representation of Content and Activity statements, Independent Statements and Questions (ref. Table 60). Also note that the collaborative learning design saw 98% of all Content contributions made by students and only 2% made by the teacher (ref. Table 59, Table 60).

T04_2006S1	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	1	0	0	0	0	1	0	0	2
Activity	3	22	0	0	0	3	0	1	29
Technology	0	1	0	0	0	0	0	0	1
Activity-Content	3	0	0	0	0	0	0	0	3
Activity-Technology	4	11	0	0	0	0	0	0	15
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	0	6	0	0	0	3	0	0	9
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	0
Totals	11	40	0	0	0	7	0	1	59

Table 59 – Topic 4 Iteration 2 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T04_2006S1	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	7	53	0	0	17	19	0	2	98
Activity	5	23	1	2	17	18	2	0	68
Technology	0	0	0	0	0	0	0	0	0
Activity-Content	2	3	0	0	0	2	0	1	8
Activity-Technology	3	5	0	2	10	4	0	0	24
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	0	2	0	0	0	4	0	1	7
Unrelated/Unclassifiable	4	7	0	3	5	7	0	0	26
Totals	21	93	1	7	49	54	2	4	231

Table 60 – Topic 4 Iteration 2 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Learning Episode 12 (Topic 4 – Iteration 3)

Activity Design: Group-work Tutorial Answer
Interface Design: Collaborative
Number of students: 3
Duration: 7 minutes

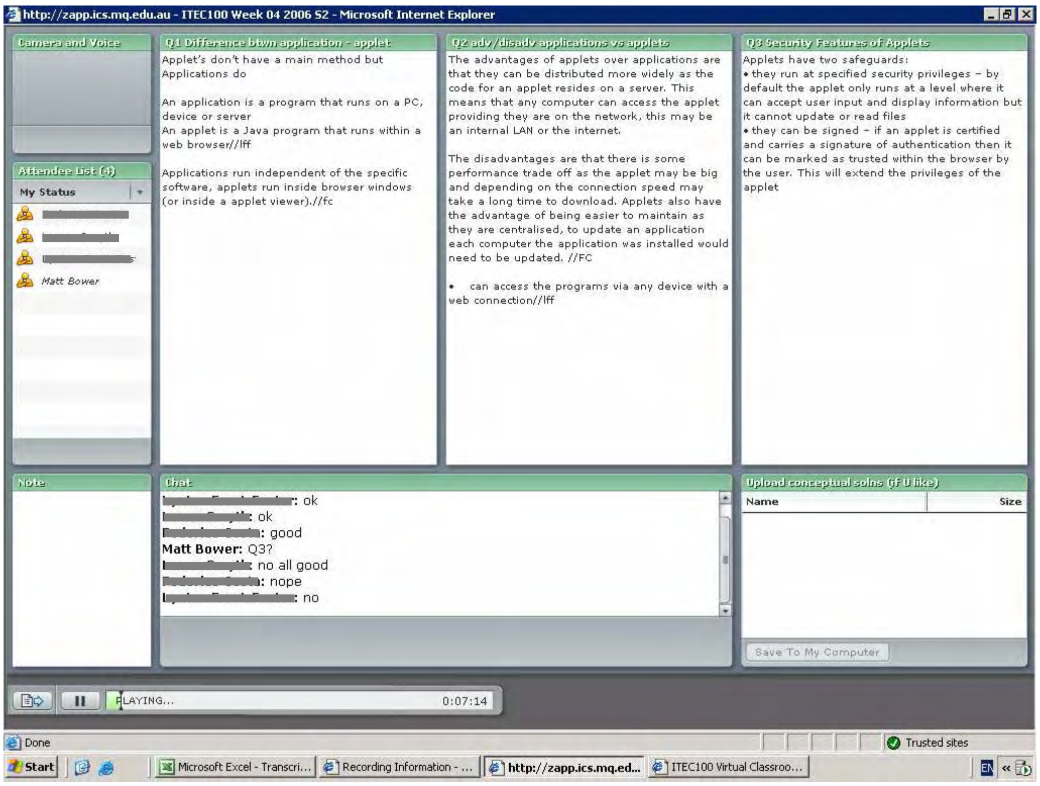


Figure 142 – Interface for episode in Topic 4 Iteration 3

Summary of episode:
This learning episode utilized the same interface as Iteration 2, except students used audio. The teacher took a more assertive role in this Iteration 3 implementation than Iteration 2, making 43 audio textual discourse contributions and 2 text-chat contributions in an only 7 minute episode (ref. Table 32). Examples of ways the teacher was more active include initially allocating one student to each question and recapitulating student solutions using audio. As well, the teacher directed students to place their initials after contributions to the note-pod to allow the identity of the contributor to be known (a strategy to overcome a collaborative constraint of the note-pod tool). The teacher specified rules and division of labour in order to improve the efficiency of the activity. Eighteen of the teacher contributions were Content textual discourse while 13 were Activity discourse (ref. Table 61).

Even though audio was available, students chose to use the chat-pod to collaborate. The extensive teacher commentary to start the episode occurs in combination with very little discourse outside the note-pods. Students only made 6 textual discourse contributions through the text-chat pod, and 15 through the note-pod as solutions (ref. Table 33). Eighteen of the 21 Contributions were Content Responses to teacher discourse (ref, Table 62). When asked if they wanted to ask any questions all students declined.

This Iteration 3 implementation was much faster than in Iteration 2 (7 minutes as opposed to 17.25 minutes). There was no time required to split the class into groups, there were more complete teacher directions to students about how to collaborate. There are many possible reasons for the student inactivity, including teacher dominance, a task prescription that left no requirement for collaboration, or personal sentiments of students at the time.

T04_2006S2	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	1	5	0	0	0	11	0	1	18
Activity	0	9	0	0	0	0	0	4	13
Technology	0	1	0	0	0	0	0	0	1
Activity-Content	4	1	0	0	0	0	0	0	5
Activity-Technology	0	3	0	0	0	0	0	0	3
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	2	1	0	0	0	1	0	1	5
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	0
Totals	7	20	0	0	0	12	0	6	45

Table 61 – Topic 4 Iteration 3 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T04_2006S2	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	0	0	0	0	3	15	0	0	18
Activity	0	0	0	0	0	0	0	0	0
Technology	0	0	0	0	0	0	0	0	0
Activity-Content	0	0	0	0	0	0	0	0	0
Activity-Technology	0	0	0	0	0	0	0	0	0
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	0	0	0	0	3	0	0	0	3
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	0
Totals	0	0	0	0	6	15	0	0	21

Table 62 – Topic 4 Iteration 3 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Task 5 – “Shallow versus Deep Copies” (Topic 9)

Learning Task Analyzed: Comprehension (Conceptual)

Question:
Explain the terms “shallow copy” and “deep copy”.

Approaches:
In Iteration 1 the teacher starts by providing a purely textual approach to differentiating between a shallow and deep copy. First students are asked to describe the difference and then the teacher displays the model textual solution. This is followed by a spontaneous use of the whiteboard to draw a diagram to illustrate the difference.

In Iteration 2 a similar approach to using the whiteboard is used as Iteration 1 (without prompting students for text-chat responses or broadcasting model textual solutions). The teacher has used the whiteboard to address this concept in the previous semester and is hence more familiar with the approach. First the teacher draws a shallow copy and then asks how the diagram would be different if it were representing a shallow copy. The teacher adjusts the diagram rather than having students make adjustments. The diagram is more elaborate with two wheels rather than one (in an attempt to promote improved abstraction) and more labelling.

In Iteration 3 the teacher is prepared with a diagram illustrating a shallow copy on one half of a whiteboard, and asks students to draw a diagram representing a deep copy on the other half of the whiteboard. Representing a shallow copy and deep copy represented side by side allowing for comparison and contrast.

Learning Episode 13 (Topic 9 – Iteration 1)

Activity Design: Teacher-Centred Whiteboard Presentation
Interface Design: Collaborative
Number of students: 9

Duration: 11.75 minutes

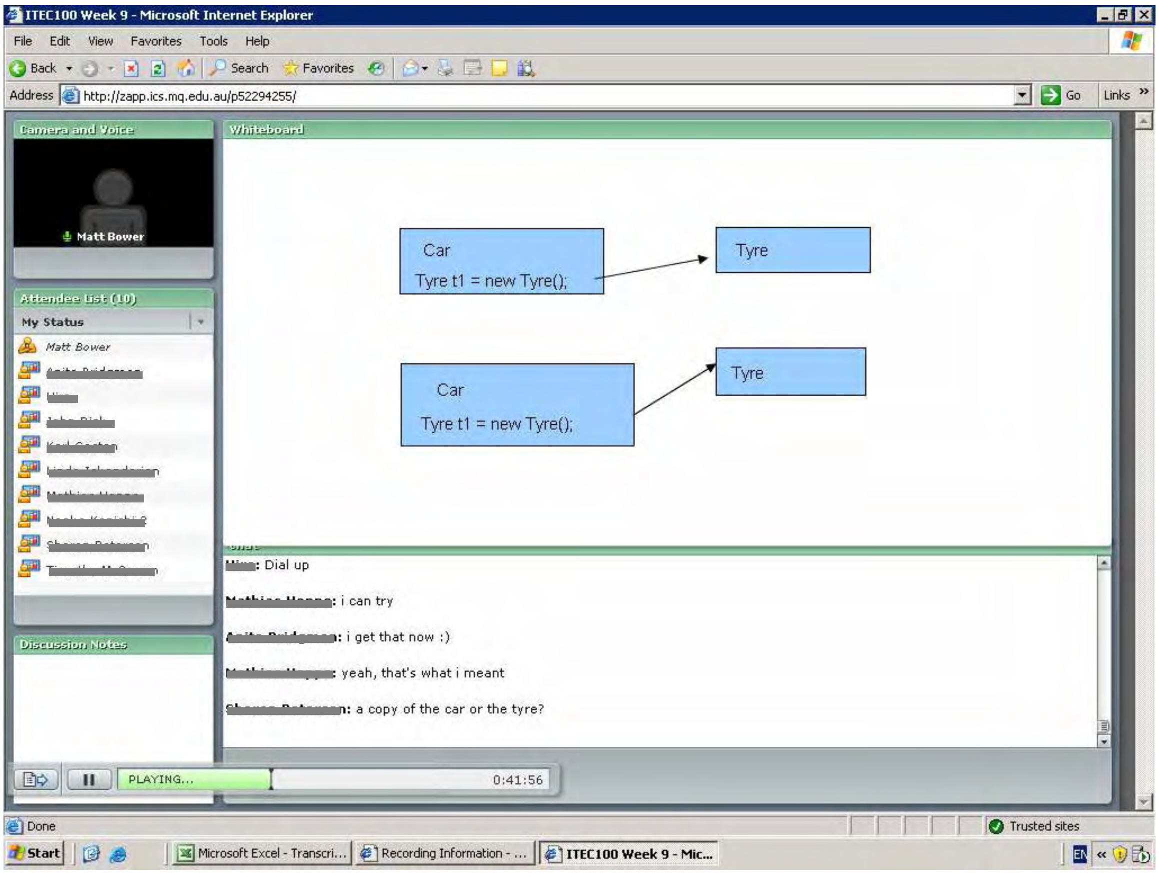


Figure 143 – Interface for episode in Topic 9 Iteration 1

Summary of episode:
Initially the tutorial solution was shared using the standard sharing interface with the chat-pod stretched across the bottom of the window. The teacher initially asked for student solutions to the question, and a student posted a standard text-book answer (in text). The teacher then broadcasted the model answer to the question (textual, pre-prepared document). Through two students' questions the teacher perceived that the concepts of shallow-copy and deep-copy are still not well formed in students' minds, and so spontaneously decided to illustrate the concepts on the whiteboard.

The teacher changed the sharing pod to contain a whiteboard and completed 12 whiteboard actions to draw a diagram representing a deep copy (see Figure 143). This took 3 minutes and the teacher vocalized his struggle to use the whiteboard. Specific issues included difficulty in maneuvering objects, in adding labels, and the inability to copy and paste. The whiteboard difficulties resulted in seven teacher Technology statements (ref. Table 63), which interrupted the flow of the lesson. The diagram itself was less than optimal, with no labelling differentiating the Car objects, or the Tyres. However the whiteboard does allow a deep copy to be represented using a concrete model that interrelates components of the concept and reduces the amount of items that need to be stored in working memory (lessening cognitive/functional load) as compared to the text description.

Students are then asked how a shallow copy would be represented on the whiteboard. Students also indicated difficulty in understanding features of the whiteboard, specifically, that they could not see the whiteboard tools (because they had not clicked on the pallet button to reveal them). A troubleshooting conversation ensued to help students better understand and use the whiteboard. This accounts for the eight teacher responsive Activity-Technology comments (ref. Table 63) and the 11 student Activity-Technology statements (ref. Table 64).

Even though a student offered to represent the shallow copy on the whiteboard, they do not do so immediately and the teacher decided to make the required adjustments to the diagram himself. The teacher responded to a further student question about the relationship between shallow copies and cloning with an extensive audio response (synchronized with five extra whiteboard actions that utilize the diagram that has been drawn). At the end of the episode students indicated that understanding has been clarified.

In this learning episode the teacher made 75 comments through the audio (Table 32), while students make 39 textual discourse contributions through the text-chat pod (ref. Table 33). The dynamic redesign of the interface to provide a whiteboard explanation was compromised by the quality of the representation and the lack of familiarity with how to use the tool (both on the part of the teacher and the students). It should also be noted that the text-chat mode of student discourse used in conjunction with the whiteboard meant that attention becomes split between the two visual modes of collaboration. Using audio with the whiteboard would overcome this by drawing upon the Modality Principle (Low & Sweller, 2005).

The spontaneous attempt to divulge some responsibility for the explanation to students was unsuccessful because the teacher eventually subsumed control of knowledge provision due to difficulties students were experiencing in operating the technology. This meant that it was not possible for students to demonstrate their level of mental model formation.

T09_2005S2	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Respons to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	4	13	0	0	4	2	0	0	23
Activity	1	7	1	1	0	0	0	0	10
Technology	1	4	0	1	0	1	0	0	7
Activity-Content	4	1	0	1	0	0	0	0	6
Activity-Technology	0	1	0	4	0	4	0	1	10
Activity-Content-Tech.	1	0	0	0	0	0	0	0	1
Content-Technology	0	1	0	0	0	0	0	0	1
Task sentiments/attitudes	0	7	0	0	0	6	0	0	13
Unrelated/Unclassifiable	0	1	0	0	0	4	0	0	5
Totals	11	35	1	7	4	17	0	1	76

Table 63 – Topic 9 Iteration 1 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T09_2005S2	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	1	0	1	0	7	3	0	2	14
Activity	0	1	1	0	1	0	0	1	4
Technology	0	1	0	0	0	0	0	0	1
Activity-Content	0	0	0	0	0	0	0	0	0
Activity-Technology	0	3	0	0	8	0	0	0	11
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	0	2	0	0	1	3	0	0	6
Unrelated/Unclassifiable	0	2	0	0	0	1	0	0	3
Totals	1	9	2	0	17	7	0	3	39

Table 64 – Topic 9 Iteration 1 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Learning Episode 14 (Topic 9 – Iteration 2)

Activity Design: Teacher-Centred Whiteboard
Interface Design: Collaborative
Number of students: 7
Duration: 8.5 minutes

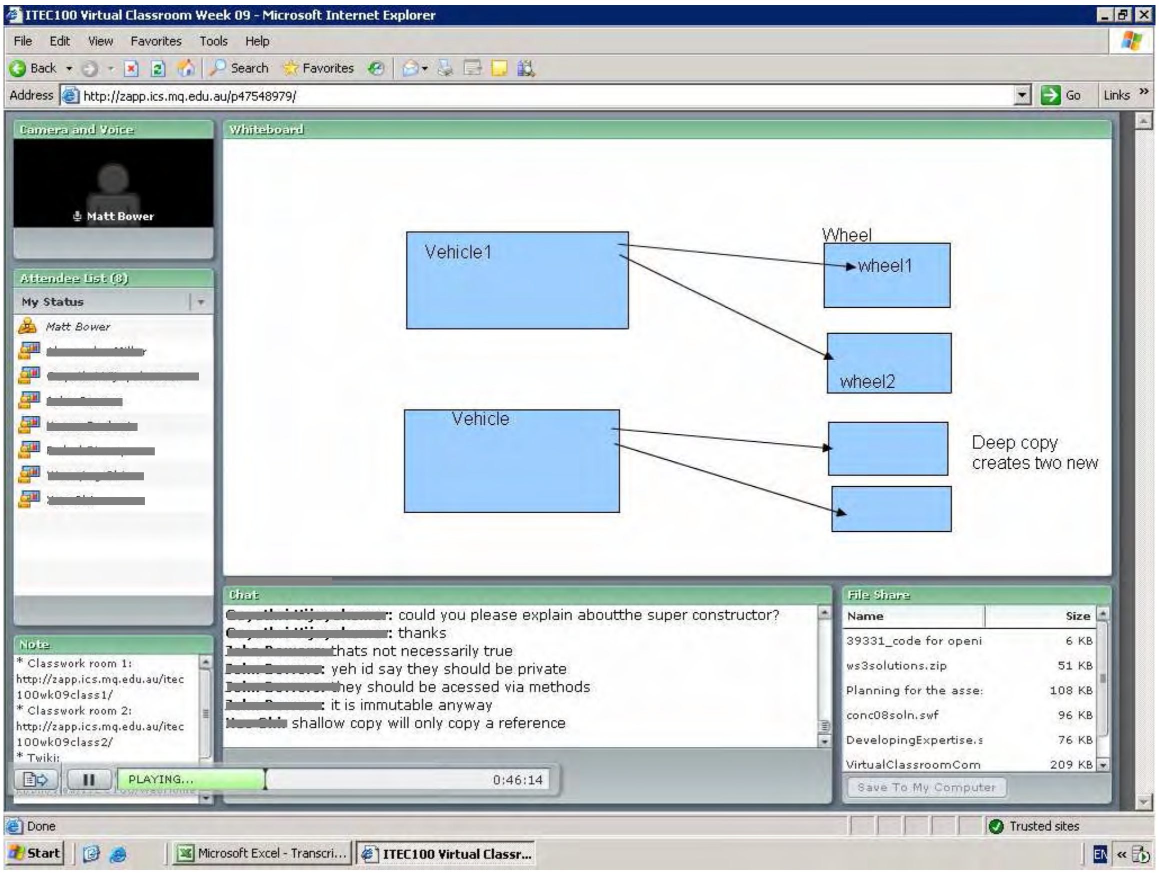


Figure 144 – Interface for episode in Topic 9 Iteration 2

Summary of episode:
Based on the experience of the previous iteration the teacher directly moved to a whiteboard in order to explain the difference between shallow copies and deep copies without asking for textual responses by the students or broadcasting model textual solutions. However the standard interface was still being used and no pre-design of the whiteboard occurred. Also based on the experience in the previous iteration the teacher controlled the whiteboard, meaning that there was no troubleshooting discourse required between the teacher and the students regarding the use of the whiteboard.

Because of the immediate movement to using the whiteboard and lower amounts of troubleshooting discourse there were only 43 audio teacher textual discourse contributions in Iteration 2 as opposed to 77 in Iteration 1 (ref. Table 32). The lower amount can also be explained by the less elaborate responses to student questions. This approach was applied in order to reduce the time spent on this task (due to general time pressures in the lesson). Correspondingly, the duration of the Iteration 2 episode is only 8.5 minutes as opposed to 11.75 minutes in Iteration 1.

While the teacher is more prepared to move directly from the presentation layout to the whiteboard based on the experience of the previous semester, he still struggled with using the whiteboard efficiently which results in six Technology statements (ref. Table 65). Eventually the teacher explained how a deep copy differs from a shallow copy using a diagram he drew on the whiteboard. In this Iteration there were 28 out of the 43 teacher textual discourse contributions were content related as compared to 30 out of 76 in Iteration 2 (ref. Table 65, Table 63), indicating a significantly greater emphasis on Content by proportion ($\chi^2 = 6.501$, $p = 0.011$, d.f. = 1, ref. Statistical Test 15).

Students only posted 8 textually discourse contributions through the text-chat pod as opposed to 39 in the previous semester (ref. Table 33). All of these were responsive Content comments (ref. Table 66). This data supports the notion that teacher dominance in a learning episode can lead to lower amounts of student contribution. While the interface was used to provide a more efficient presentation in this iteration than Iteration 1, students were still not provided with the opportunity to actively engage in the episode or demonstrate their level of understanding.

T09_2006S1	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	**Totals**
Content	3	14	0	0	6	0	0	0	**23**
Activity	0	2	0	0	0	0	0	0	**2**
Technology	0	6	0	0	0	0	0	0	**6**
Activity-Content	2	3	0	0	0	0	0	0	**5**
Activity-Technology	0	3	0	0	0	0	0	0	**3**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	3	0	0	0	1	0	0	**4**
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	**0**
Totals	**5**	**31**	**0**	**0**	**6**	**1**	**0**	**0**	**43**

Table 65 – Topic 9 Iteration 2 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T09_2006S1	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	0	0	2	0	6	0	0	0	8
Activity	0	0	0	0	0	0	0	0	0
Technology	0	0	0	0	0	0	0	0	0
Activity-Content	0	0	0	0	0	0	0	0	0
Activity-Technology	0	0	0	0	0	0	0	0	0
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	0	0	0	0	0	0	0	0	0
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	0
Totals	0	0	2	0	6	0	0	0	8

Table 66 – Topic 9 Iteration 2 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Learning Episode 15 (Topic 9 – Iteration 3)

Activity Design: Student-Centred Whiteboard Activity
Interface Design: Collaborative
Number of students: 4
Duration: 6.75 minutes

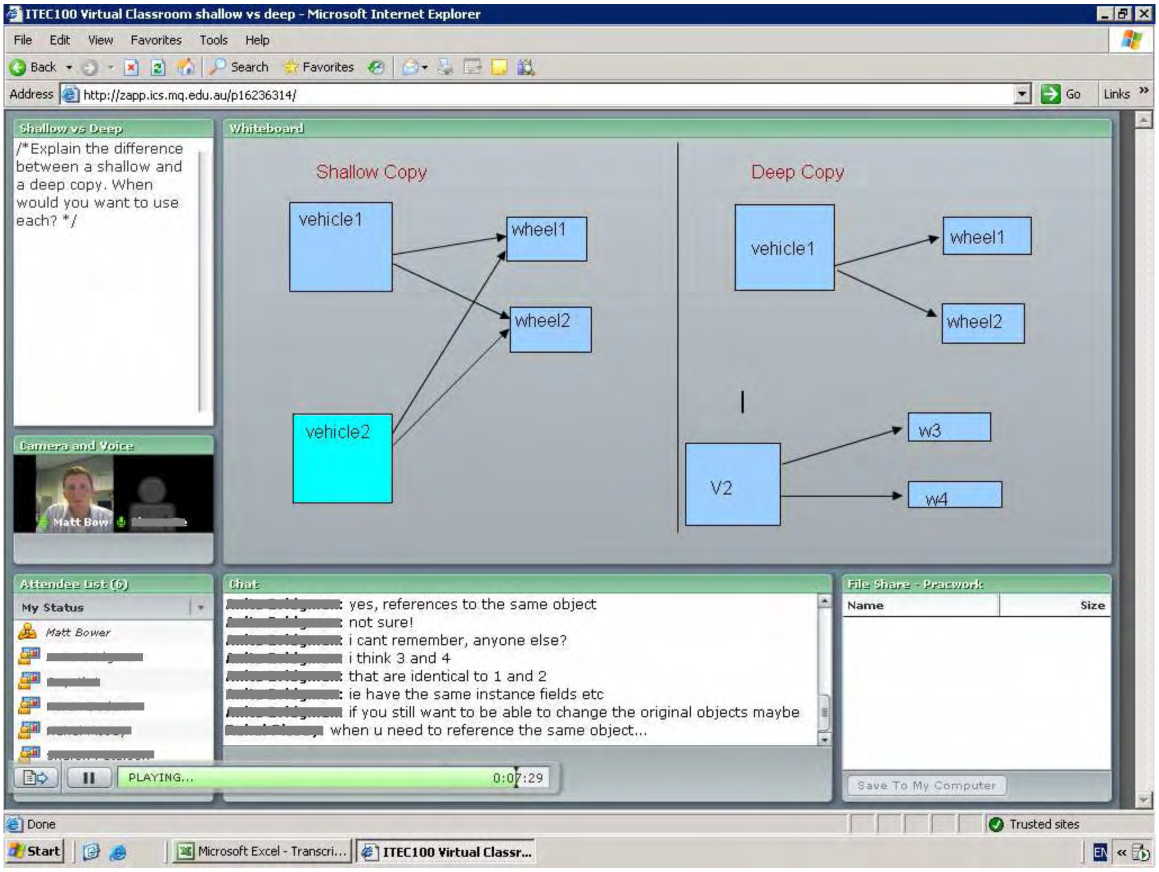


Figure 145 – Interface for episode in Topic 9 Iteration 3

Summary of episode:
In this episode the teacher had purpose designed a layout in preparation for the task. A shallow copy is represented on the left hand side of the whiteboard, and students were then asked to represent a deep copy on the right hand side (see Figure 145). Note that this intrinsically provides students with a model of how to represent objects, variables and references so that they did not have to spend time deriving their own representation system. As recommended by the Laurillard's (2002) Conversational Framework, students have both the opportunity to apprehend the form of representation and then consolidate their mental models by applying those semiotic representations.

Some students use audio while others use text-chat. The use of audio prevented the splitting of attention that could occur if students attempted to simultaneously use the two visual modes of communication (text-chat and whiteboard). Altogether students make 11 text-chat pod discursive contributions and 10 audio contributions (ref. Table 33). Of the 21 textual-discourse contributions by students, 19 are Content contributions. All of the eight whiteboard contributions are from students (ref. Table 33). That is to say, the pre-designing the interface for collaboration provided more opportunity for student engagement with curriculum matter.

The teacher made 40 audio textual discourse contributions, as well as one text-chat prompt (ref. Table 32). Of those 41 comments, 21 are content related whereas 19 are activity related (ref. Table 44). Thus under this learning design approximately the same amount of teacher energy is spent coordinating and encouraging activity as addressing curriculum matters. The teacher handed over responsibility for representing the concept of a deep-copy to students and as such the teacher made no whiteboard contributions (ref. Table 32). This is in contrast to Iteration 1 and Iteration 2 where the teacher dominated both discussion and whiteboard contribution. As such students are provided with the opportunity to collectively negotiate meaning and demonstrate a shared mental model. The teacher could then instantly assess that a relational understanding had been achieved amongst the group, because the whiteboard allowed users to demonstrate the interrelations between knowledge units in a way that text-chat cannot.

This Iteration was the quickest of the three approaches (6.75 minutes as compared to 8.5 in Iteration 2 and 11.75 in Iteration 1). This was mainly due to pre-preparation of the whiteboard and interface for the learning task. Even though there was a greater delegation of activity to the students in Iteration 3 compared to Iteration 1 (where students were also responsible for a minor contribution to the whiteboard), there was less Technology related discourse (2 out of 21 comments in Iteration 3 relate to technology as opposed to 12 out of 39 comments in Iteration 1, ref. Table 68 & Table 64). Students were more familiar with how to use the technology to collaborate which improved the efficiency with which the learning episode was conducted.

T09_2006S2	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	3	6	0	1	0	6	0	0	16
Activity	1	4	0	0	0	2	0	0	7
Technology	0	0	0	0	0	0	0	0	0
Activity-Content	2	1	0	1	0	0	0	0	4
Activity-Technology	2	2	0	0	1	0	0	1	6
Activity-Content-Tech.	0	2	0	0	0	0	0	0	2
Content-Technology	0	1	0	0	0	0	0	0	1
Task sentiments/attitudes	0	2	0	0	0	0	0	2	4
Unrelated/Unclassifiable	0	1	0	0	0	0	0	0	1
Totals	8	19	0	2	1	8	0	3	41

Table 67 – Topic 9 Iteration 3 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T09_2006S2	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	2	2	1	1	12	1	0	0	**19**
Activity	0	0	0	0	0	0	0	0	**0**
Technology	0	1	0	0	0	0	0	0	**1**
Activity-Content	0	0	0	0	0	0	0	0	**0**
Activity-Technology	0	0	1	0	0	0	0	0	**1**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	0	0	0	0	0	0	0	**0**
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	**0**
Totals	**2**	**3**	**2**	**1**	**12**	**1**	**0**	**0**	**21**

Table 68 – Topic 9 Iteration 3 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Task 6 – "RadioButton to ComboBox" (Topic 10)

Learning Task Analyzed: Meet a design specification (Procedural)

Question:
Adjust the program your wrote in the pre-class activities that changed the background colour of a panel using radio-buttons so that it now changes the colour using a dropdown menu.

Approaches:
In Iteration 1 the teacher broadcasts their desktop containing the IDE and prompts students for suggestions about how to change the program so that it uses a dropdown menu instead of radio-buttons (teacher-led design).

In Iteration 2 students complete the task in purpose built group-work rooms, with the teacher moving between the two rooms to observe their work.

In Iteration 3 the three students complete the task using the same group-work room as Iteration 2. A note-pod is used to write the program. Although the teacher is present in the group-work room, a deliberate effort is made to remove himself from the activity to allow the students to direct the exercise.

Learning Episode 16 (Topic 10 – Iteration 1)

Activity Design: Teacher-Led Programming
Interface Design: Presentational
Number of students: 8
Duration: 21.5 minutes

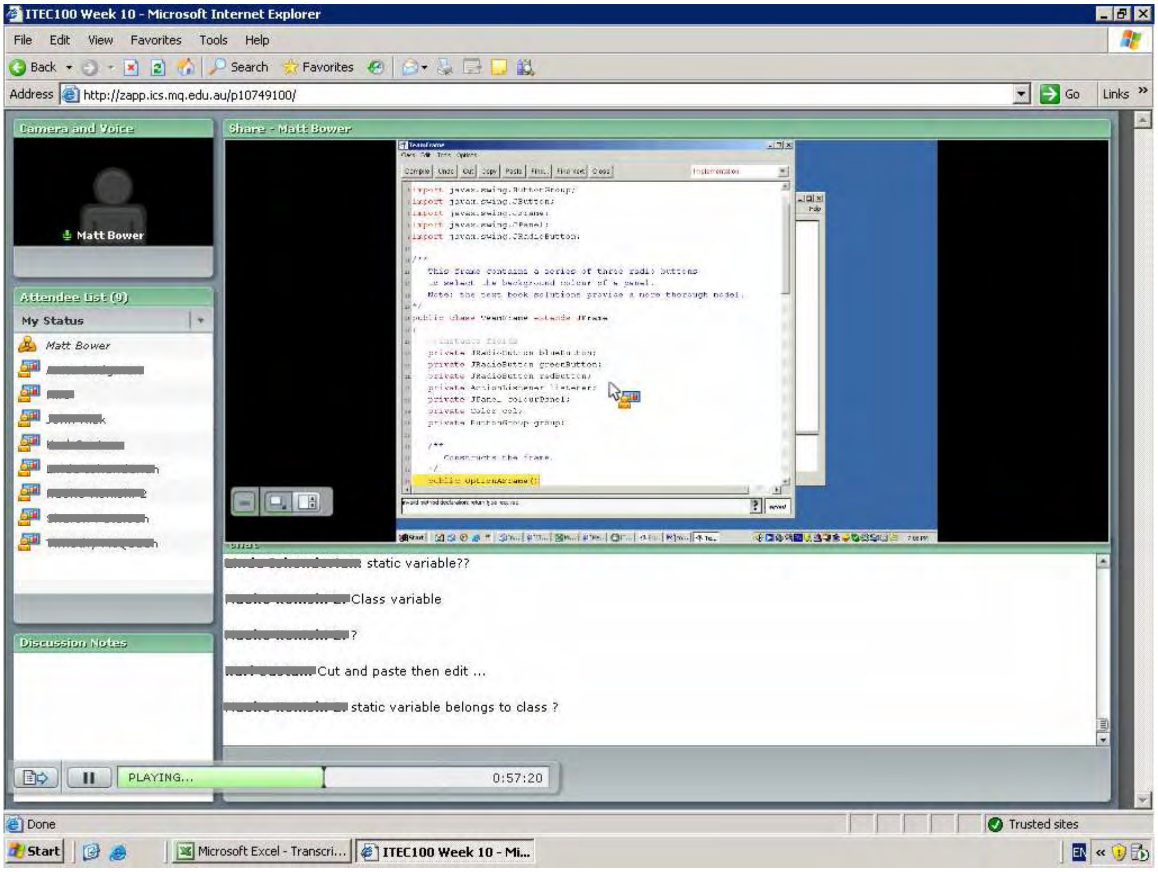


Figure 146 – Interface for episode in Topic 10 Iteration 1

Summary of episode:
Initially the teacher was broadcasting the task description from the tutorial sheet that has been uploaded to the web-conferencing system. Then the teacher broadcasted their screen so as to lead the class programming activity. A standard desktop sharing interface was used, although once again the text-chat pod had been enlarged across the bottom of the screen to allow more written discourse to be read at once (see Figure 45). While broadcasting his IDE the teacher asked students prompting questions to encourage suggestions about how to solve the programming problem. Students could make contributions of code through the text-chat pod which the teacher could then choose to directly use in the program.

The teacher made several decisions about how to solve the problem and performed intermediary steps without waiting to receive complete instructions from the students. For instance, the teacher could take a suggestion like "make the panel bigger" (a reference to the panel in the computer program being written) and write all the code to implement that if he so chose. The teacher-led programming activity design allowed the teacher to demonstrate how to adjust programs and articulate logic relating to the task. The process of debugging code can also be demonstrated, with the class able to offer debugging suggestions at each obstacle. That is to say, all students have a chance to be involved and engaged, even though they are not at the centre of control of the activity.

The implementation of the learning design resulted in 60 separate recorded instances of modelling programming actions (ref. Table 32). Four instances of the teacher highlighting text to provide emphasis were also recorded (ref. Table 32). As well, on two occasions the teacher pasted code suggested by the students in the text-chat pod to the IDE, but this involved the inefficient transition back the web-conferencing environment in order to make the copy (ref. Table 32). With the range of interfaces and approaches adopted the teacher required several different technological competencies to conduct this episode. However no difficulties with the communication approaches were experienced and as such no Technology or Technology related discourse contributions were recorded (ref. Table 8).

On the other hand, students only used text-chat to participate in this task, contributing a total of 64 textual discourse contributions using this means (ref. Table 33). Of these 64 contributions, none are Technology or Technology related (ref. Table 9) – students were adequately familiar with the mode of interaction associated with teacher-led programming. Of the 36 Content comments made by students, most (19) are Statement Responses to Questions (ref. Table 9). This is explained by the learning design whereby the teacher prompts for student suggestions about what to do next. However implementation of the design also provides space for students to direct learning with three Independent Student Questions and eight Independent Statements all relating specifically to Content (ref. Table 9). Students also make 10 Activity-Content statements (ref. Table 9). These resulted from providing explicit directions to the teacher about the steps that should be performed to solve the problem, such as "add the panel".

All 126 of the teacher textual discourse contributions were made using audio (ref. Table 32). The teacher made 12 Activity statements relating to how students should be engaging in this task (ref. Table 8), many of which occur at the beginning of the task, such as "I'm just a robot and you've got to tell me what things we need to change". This set the expectation for activity during the learning episode. The teacher also made 18 Activity-Content statements throughout the task, with a large proportion occurring at the beginning of the learning activity to set up how the class should interact with the content (for example, "And what we're going to do is turn the code that we have into a dropdown menu"). The learning design often placed the teacher in a responsive role; 37 of the 126 textual discourse contributions made by the teacher were responses to student questions or statements (ref. Table 8).

There is a degree of enthusiasm and excitement expressed once the problem is solved. This explains the large number of sentiment and attitude comments (10 by students, ref. Table 9, and 15 by the teacher ref. Table 8). However it is still only possible to assess that students have a multistructural level of understanding because they did not evidence they could complete all aspects of the problem solving process.

T10_2005S2	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	16	36	1	2	7	13	0	2	77
Activity	1	8	0	0	3	0	0	0	12
Technology	0	0	0	0	0	0	0	0	0
Activity-Content	2	9	0	1	0	6	0	0	18
Activity-Technology	0	0	0	0	0	0	0	0	0
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	3	7	0	0	0	4	0	1	15
Unrelated/Unclassifiable	1	2	0	0	0	0	0	1	4
Totals	23	62	1	3	10	23	0	4	126

Table 69 – Topic 10 Iteration 1 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T10_2005S2	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	3	8	3	1	19	2	0	0	36
Activity	3	2	0	0	1	1	0	1	8
Technology	0	0	0	0	0	0	0	0	0
Activity-Content	0	6	0	0	2	2	0	0	10
Activity-Technology	0	0	0	0	0	0	0	0	0
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	0	5	0	0	4	1	0	0	10
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	0
Totals	6	21	3	1	26	6	0	1	64

Table 70 – Topic 10 Iteration 1 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Learning Episode 17 (Topic 10 – Iteration 2)

Activity Design: Group Programming
Interface Design: Collaborative
Number of students: 7
Duration: 32.75 minutes

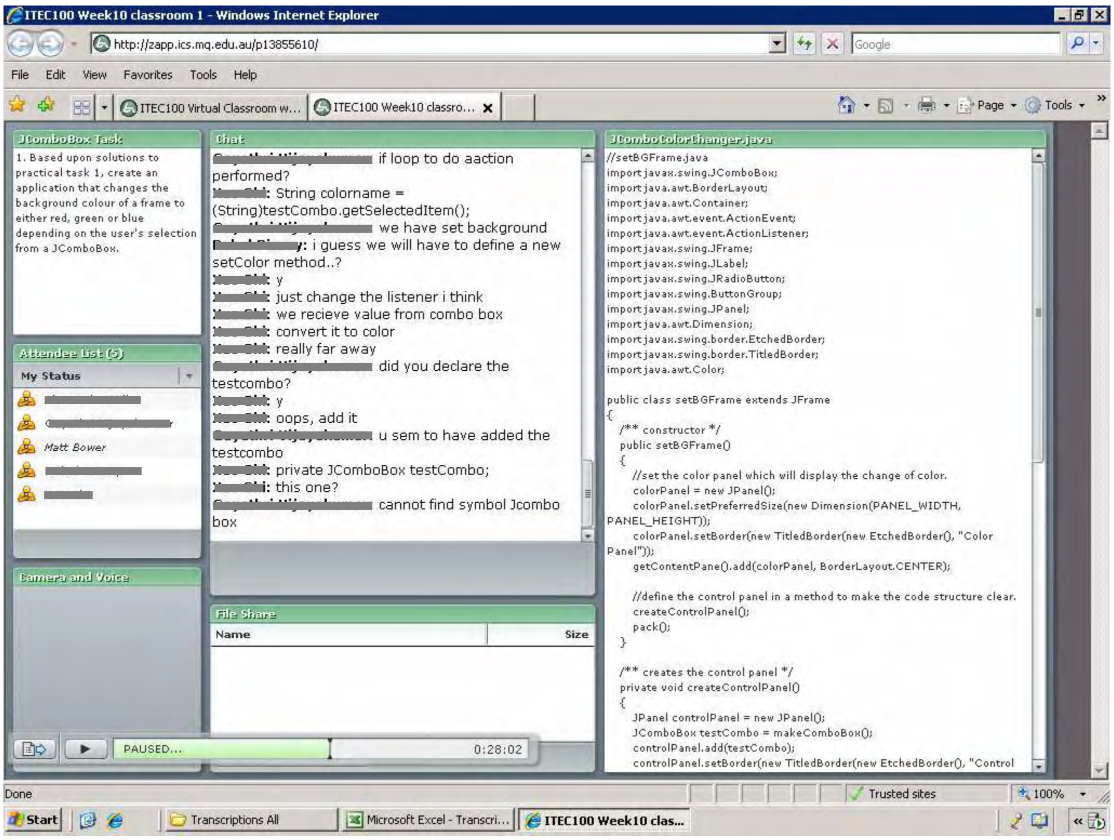


Figure 147 – Interface for episode in Topic 10 Iteration 2

Summary of episode:
In this implementation of the exercise students completed the programming task in groups using rooms that had been specifically designed for the activity (see Figure 46). The task was specified in the top left note-pod. The text-chat pod was larger to allow more student textual discourse to be reviewed at one time. There was a file-share pod for students to share programming files, though this was not used.

There were several affordance differences observed between using the note-pod solution space approach of this iteration as opposed to the screen-sharing approach of Topic 3 Iteration 2. Firstly, students all had equal access to the large note-pod as opposed to previous approaches where one student broadcasts their screen with the IDE running. As well, students could (and did) copy and paste several (sometimes dozens of) lines of program code if required, which was not possible using the text-chat pod during a screen-sharing session.

There are trade-offs against these advantages of the note-pod approach to group programming. Students run into version control problems if they copy the code from the note-pod into their IDE and make adjustments – they have to merge these changes back into the note-pod. As well, scrolling on the note-pod is not synchronized between participants, meaning it is difficult to coordinate a common point of focus if students are collaborating about changes. Further, whereas with screen-sharing the identity of the editor is known, in the note-pod there is no way to review who has made a contribution. Finally, with screen-sharing highlighting can be used to focus attention on particular lines of code. These last three factors all contribute to distributed process loss. They also make the process aspects of the activity harder for the teacher to monitor.

The teacher switched between the two student group-work rooms 12 times throughout the learning episode (ref. Table 32), in order to monitor student progress. The teacher used audio broadcast to encourage student contribution and occasionally make suggestions. At one stage during the episode the teacher set up the next task in the main room while students are working in their groups, resulting in the 15 actions relating to another task (ref. Table 32). The teacher responded less about Content in this learning design than in Iteration 1, with only 4% of textual discourse being Content responses to students (6 out of 140 comments, ref. Table 10) as opposed to 18% in Iteration 1 (23 out of 126 comments, ref. Table 8).

After 21.5 minutes neither group has finished and the teacher recommended that they finish the task at home so that they can move onto the next activity. However some students were highly engaged with the task and prefer to still work on it in the group rooms. There was an extended period of hesitation from the teacher about whether to move on to the next activity or finish the current task, and the teacher in fact commences the next task regarding graphical user interface design. Thirty minutes after the original group programming task commenced a student declared that they had completed it, so the teacher returned to demonstrate the student's work.

More time in this iteration was wasted as the teacher forgot to share his screen when broadcasting the testing of the student's solution, resulting in a minute being lost and the process being repeated. In the last two minutes of the learning episode the teacher demonstrates the student's (correct) solution, which explains the 11 Modelling Programming actions (ref. Table 32).

The duration of the student-centred Iteration 2 was 32.75 minutes as opposed to 21.5 minutes for the teacher-led programming approach of Iteration 1. Firstly, there was a collaborative overhead caused by having to organize students into groups and move people to rooms. The teacher also spent some time suggesting how students should commence with the task; for instance recommending that they use a particular student's attempt at the RadioButton exercise. When the teacher was coordinating the activity in Iteration 1 he could choose to accelerate the pace of the learning episode as required, by "filling in the blanks". Thus it stands to reason that the student-led group-work approach took longer.

Students posted 147 textual discourse contributions using the chat pod, as compared to 64 in the teacher-led programming learning design of Iteration 1 (ref. Table 33). As well, instead of the teacher making all the programming actions in Iteration 1 (60 in total, ref. Table 32) the students in their two groups make 73 note-pod actions relating to creating the required program (ref. Table 33). The student-centred activity design enabled far greater student involvement.

Of the 147 student textual discourse contributions 66.7% were activity related (49 Activity, 42 Activity-Content, 7 Activity-Technology, ref. Table 11). The larger than usual proportion of Activity-Content contributions was due to students negotiating with one another about how to collaboratively perform the problem solving process, with statements like "lets define the getSelected [method] now". Only 29% are purely Content contributions (43 out of 147, ref. Table 11), as opposed to 56% in Iteration 1 (36 out of 64, ref. Table 9). This is a highly significant difference ($\chi^2 = 13.9$, $p = 0.0002$, d.f. = 1, ref. Statistical Test 16). The explanation for this difference appears to be that teacher coordination role in the teacher-led Programming design allowed students to focus more directly on Content than in the Group Programming design where students were responsible for coordinating activity.

There was a much higher proportion of student Independent Questions using this group programming learning design than the teacher-led programming design of Iteration 1. Twenty-five out of 147 student textual discourse contributions were independently initiated (17%) as opposed to six from 64 or 9% in Iteration 1 (ref. Table 9, Table 11). As well, the majority of student responses to questions and statements were to their peers rather than to the teacher.

The task was ill-structured to the extent that students were given an authentic problem with no process based scaffolding. As a qualitative observation, the focus of student discussion in this exercise is at times both specific and deep. The authentic, meaningful task requiring students to collaborate in order to derive a solution may have contributed to the quality of their engagement.

The solution that each group presented allows the shared understanding of students to be assessed. Because students contributed to all aspects of the problem solving process, a correct solution indicated the group (though not individuals) attained a relational level of understanding. Because the task allows the teacher to be present during the process of students forming their understanding there is greater opportunity to provide cognitive support at the time it is most required (as opposed to when the product is being reviewed and students' mental models are already formed, either accurately or inaccurately)

As in previous collaborative activities, the note-pod solution space acts as a filter. Only programming code is entered into that space and not any Activity or Technology related textual discourse.

T10_2006S1	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	0	13	0	0	3	3	0	1	**20**
Activity	13	42	0	1	0	3	0	4	**63**
Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content	4	5	0	0	2	3	0	0	**14**
Activity-Technology	3	16	0	1	0	0	0	3	**23**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	6	0	0	0	6	0	0	**12**
Unrelated/Unclassifiable	0	8	0	0	0	0	0	0	**8**
Totals	**20**	**90**	**0**	**2**	**5**	**15**	**0**	**8**	**140**

Table 71 – Topic 10 Iteration 2 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T10_2006S1	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	9	11	0	7	14	2	0	0	**43**
Activity	6	10	0	3	16	11	1	2	**49**
Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content	10	11	0	4	8	5	1	3	**42**
Activity-Technology	0	6	0	0	0	1	0	0	**7**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	0	0	0	1	2	0	0	**3**
Unrelated/Unclassifiable	0	1	0	0	1	1	0	0	**3**
Totals	**25**	**39**	**0**	**14**	**40**	**22**	**2**	**5**	**147**

Table 72 – Topic 10 Iteration 2 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Learning Episode 18 (Topic 10 – Iteration 3)

Activity Design: Group programming
Interface Design: Collaborative
Number of students: 3
Duration: 36 minutes

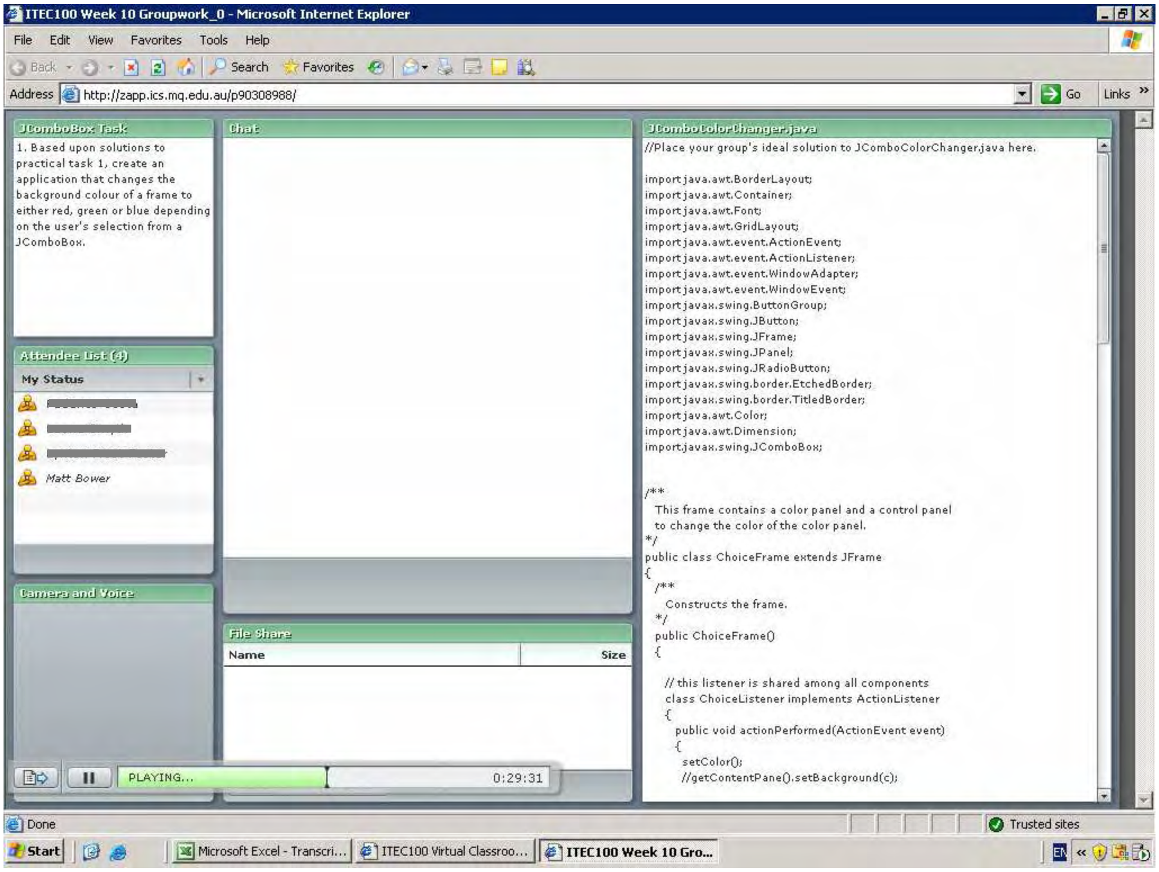


Figure 148 – Interface for episode in Topic 10 Iteration 3

Summary of episode:
In this learning episode the same group-work room interface as Iteration 2 was used for students to collaboratively write their program solution. Not only is the file-share pod unused in Iteration 3, but neither is the text-chat pod since students make all of their 263 textual discourse contributions using audio (ref. Table 33). Potentially both of these pods could have been removed for the iteration using audio which would have allowed the solution space to be larger. If other pods were needed they could have been inserted on demand.

Students made 29 note-pod non-textual discourse contributions as they collaborative write the solution to the computer programming task (ref. Table 33). Note that in this Iteration they use the convention of putting their initials preceded by a double forward slash at the end of a line of code in order to be able to identify the contributor to the note-pod each time. Students need little reminding of this because this convention has been established within the community.

There were substantially more teacher textual discourse contributions in the previous two iterations of this task as compared to Iteration 3, even though Iteration 3 was the longest. In Iteration 3 the teacher made 60 comments over 36 minutes as opposed to 140 comments over 32.75 minutes in Iteration 2 and 126 comments over 21.5 minutes in Iteration 1 (ref. Table 32). This was in part due to the teacher's conscious effort to allow students to control this task.

Of the 60 textual discourse comments that the teacher contributed only 40 out of 60 were activity related (22 Activity, 6 Activity-Content, and 12 Activity-Technology, ref. Table 12). This demonstrated the more facilitative rather than directive role that the teacher assumed. The Activity comments occurred more frequently at the commencement of the lesson, with statements such as "I'm going to say as little as possible and have you guys collaborate as much as possible". The Activity-Technology statements related to explaining how students needed to use audio and be typing in the note-pod, and at one point asking whether they would prefer to be using screen-share (an offer that they declined).

The teacher only made seven Content contributions throughout the entire 36 minute learning episode. That is to say, even though this was the longest learning episode of any analyzed in this dataset, it resulted in the least teacher Content contributions. This supports the notion that the teacher's intention (both actual and that perceived by the students) may be a significant factor influencing the type of collaborative patterns that ensue in a lesson.

The 263 student textual discourse contributions made in Iteration 3 is a substantially greater number than the 147 in Iteration 2 and the 64 in Iteration 1 (ref. Table 33). It is worth noting that even though the duration of the Iteration 3 learning episode is 3.25 minutes or 10% longer than Iteration 2, there were only three students as opposed to seven. One potential reason for the larger rate of contribution per person is the capacity for audio to allow more rapid and conversational textual discourse contribution. Another contributing factor could be that audio can overlay note-pod contributions without splitting students' attention as is the case when the note-pod and text-chat are used together (Modality principle, Low & Sweller, 2005).

The increase in teacher modelling programming actions from 11 in Iteration 2 to 29 in Iteration 3 (ref. Table 32) was due to the in-lesson decision to perform group debugging using the IDE via the teacher's screen-share once the program had reached a certain level of formedness. Note that this was less than the 60 that occurred in Iteration 1 of this learning episode (ref. Table 32) where the teacher led the entire programming process via screen-share.

Of the 263 student textual discourse contributions 110 are Content contributions, 53 Activity, and 85 Activity-Content (ref. Table 13). As in Iteration 2, the higher than usual proportion of Activity-Content statements in the group programming activity were due to comments that relate both to what should be done and by whom. As in Iteration 2 a large number of independent student contributions arose during this student-centred activity design involving an authentic task, with 66 Independent Statements and 48 Independent

Questions (ref. Table 13). There was also a strong representation of Question Responses to Statements, Statement Responses to Questions and Statement Responses to Statements (21, 63, and 49, ref. Table 13). Thus students were both taking ownership of their learning and performing substantial interaction with one another. The 13 Statement Response to Actions (ref. Table 13) mainly related to student responses to other students contributions to the note-pod as part of writing the solution computer program, such as “we need it [the instance field] down the bottom”.

It should be noted that the students in this activity indicated difficulty in tracking each others’ contributions to the solution space because the scrolling of the pod contents is not synchronized. This made it difficult to know where other people are editing, and thus a collaborative overhead (distributed process loss) was incurred to coordinate this. On the other hand, like Iteration 2 of this task the level of student discussion that arose was both specific and deep.

As in Iteration 2 the learning design led to a more complete revelation of students’ mental models than in Iteration 1 and thus allowed the teacher to more accurately gauge students’ level of understanding. The process based nature of the task meant that the teacher could observe students forming their mental models and interject with remedial instruction if necessary. It should also be noted that all the advantages and disadvantages of using a note-pod as compared to a screen-share for group programming that were identified in Iteration 2 apply to Iteration 3 as well.

A variety of interactive categories being strongly represented in this learning episode (Independent Questions, Independent Statements, Question Responses to Statements, Statement Responses to Questions, Statement Responses to Statements) coincides with the teacher’s reflection that the quality of student conversation held in this activity was high. That is to say, a spread of collaborative types could be seen as an indicator of a free flowing conversation.

T10_2006S2	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	1	1	0	0	0	3	0	2	7
Activity	1	16	0	2	1	2	0	0	22
Technology	0	0	0	0	0	0	0	0	0
Activity-Content	1	3	0	1	1	0	0	0	6
Activity-Technology	3	8	0	0	0	1	0	0	12
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	1	7	0	0	1	0	0	0	9
Unrelated/Unclassifiable	0	4	0	0	0	0	0	0	4
Totals	7	39	0	3	3	6	0	2	60

Table 73 – Topic 10 Iteration 3 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T10_2006S2	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	19	21	1	7	29	29	0	4	**110**
Activity	9	9	2	7	16	5	0	5	**53**
Technology	0	0	0	2	0	0	0	0	**2**
Activity-Content	20	29	0	5	14	14	0	3	**85**
Activity-Technology	0	0	0	0	3	0	0	0	**3**
Activity-Content-Tech.	0	0	0	0	1	0	0	0	**1**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	4	0	0	0	1	0	1	**6**
Unrelated/Unclassifiable	0	3	0	0	0	0	0	0	**3**
Totals	**48**	**66**	**3**	**21**	**63**	**49**	**0**	**13**	**263**

Table 74 – Topic 10 Iteration 3 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Task 7 – "Nested Loop Array Output" (Topic 11)

Learning Task Analyzed: Prediction (Conceptual).

Question:
Draw a diagram that illustrates the arrays that are created with the following code:

```
public class TwoDtester
{
    public static void main(String[] args){
        int[][] steps = new int [4][];
        for (int i = 0; i<steps.length;i++){
             steps[i] = new int[i+1];
             for (int j = 0; j < steps[i].length; j++)
                  steps[i][j] = i+j;
         }
     }
}
```

Approaches:
In Iteration 1 the teacher uses a traditional broadcast solution accompanied with an audio description approach (teacher-centred).

In Iteration 2 the teacher attempts to represent the logic underlying the nested loop by using the IDE to step through the program (teacher-centred).

In Iteration 3 the teacher provides guidance to students on how the whiteboard can be used to dynamically emulate the computer's logic in constructing the nested loop (teacher-led).

Learning Episode 19 (Topic 11 – Iteration 1)

Activity Design: Teacher-Centred Presentation
Interface Design: Presentational
Number of students: 9
Duration: 4.5 minutes

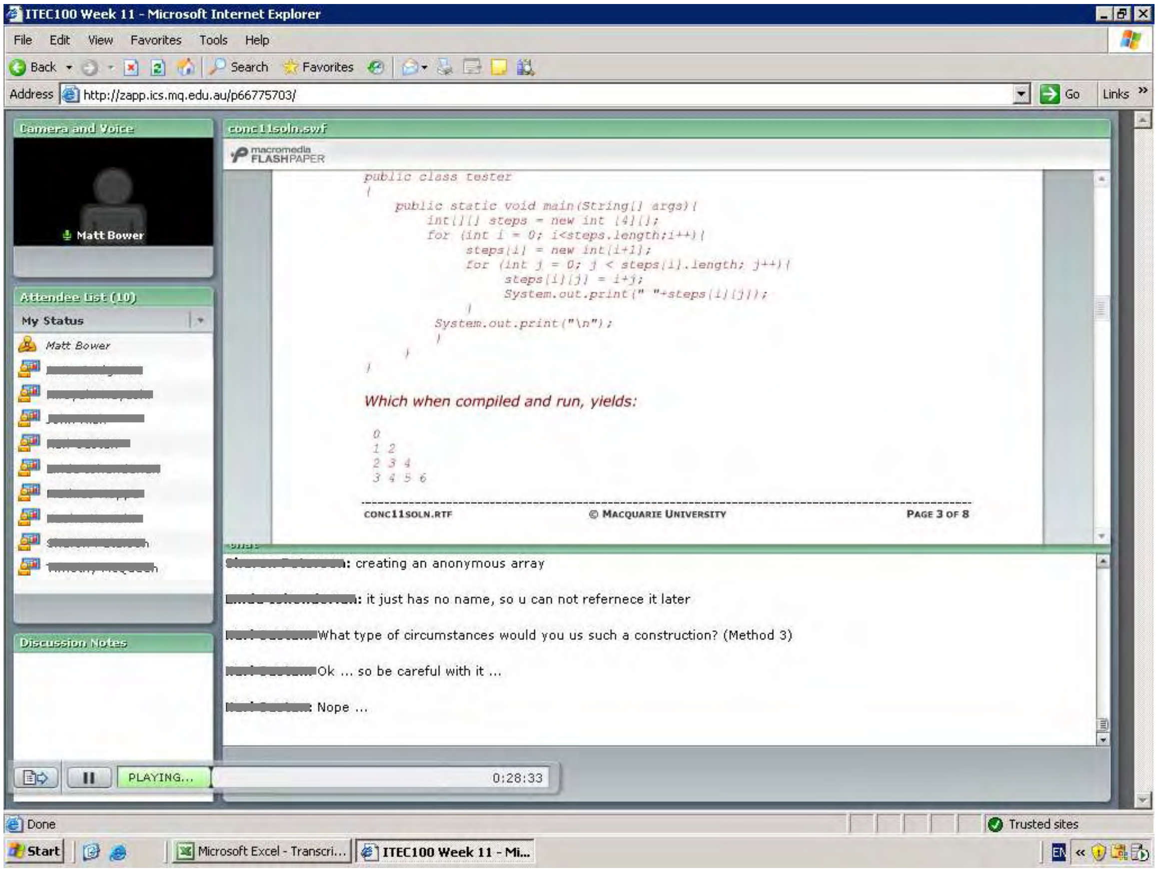


Figure 149 – Interface for episode in Topic 11 Iteration 1

Summary of episode:
This iteration used the standard interface for document broadcasting, except the text-chat spans a larger area along the bottom of the screen (see Figure 149). The teacher initially broadcasted the program on the screen and talked through the logic behind the loop. Then the teacher showed a version of the original program that prints out the contents of the two dimensional array that is formed, and attempted to explain what will be printed as a result. A segment of the teacher explanation for time (3:00 to time 3:45) is presented below, for illustrative purposes:

> *In the first iteration it prints 0. That's just saying there's the first line of steps or the first set of arrays is just a single element array with 0 in it. Steps 1 is an array with two elements, 1 and 2 in it. Steps 2 is an array with three elements in it, 2, 3 and 4. And steps 3, the fourth element of the Steps array, is an array with 4 elements in it, 3, 4, 5 and 6.*

The verbal instructions that the teacher provided are difficult to relate to the program code and the process by which the arrays are created. A visual representation of the answer was shown on the solution page that is being broadcast, however this only represents the final product. The teacher then suggested that people use the debugger to step through the program if they would like to improve their understanding of the logic underlying the code. This was followed by asking students if they had any questions.

The teacher provided their explanation in 30 audio based textual discourse contributions (ref. Table 32). All of these contributions were Independent, with 21 out of 30 being Content Independent Statements (ref. Table 75). In this Iteration there was only one student textual discourse contribution (ref. Table 33), the single text-chat response of "Nope…" to the teacher's inquiry as to whether there were any questions.

This was an example of a teacher adopting a highly transmission approach to covering a conceptual question in their class. This sort of approach may be adopted because the teacher has no alternate strategies or because they want to minimize time spent on the activity. Using this approach there was almost no interaction and hence it was not possible to properly gauge the formedness of student mental models.

T11_2005S2	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	1	21	0	0	0	0	0	0	22
Activity	0	2	0	0	0	0	0	0	2
Technology	0	0	0	0	0	0	0	0	0
Activity-Content	2	1	0	0	0	0	0	0	3
Activity-Technology	0	0	0	0	0	0	0	0	0
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	0	3	0	0	0	0	0	0	3
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	0
Totals	3	27	0	0	0	0	0	0	30

Table 75 – Topic 11 Iteration 1 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T11_2005S2	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	**Totals**
Content	0	0	0	0	1	0	0	0	**1**
Activity	0	0	0	0	0	0	0	0	**0**
Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content	0	0	0	0	0	0	0	0	**0**
Activity-Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	0	0	0	0	0	0	0	**0**
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	**0**
Totals	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**

Table 76 – Topic 11 Iteration 1 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Learning Episode 20 (Topic 11 – Iteration 2)

Activity Design: Teacher-Centred Presentation
Interface Design: Presentational
Number of students: 6
Duration: 10.5 minutes

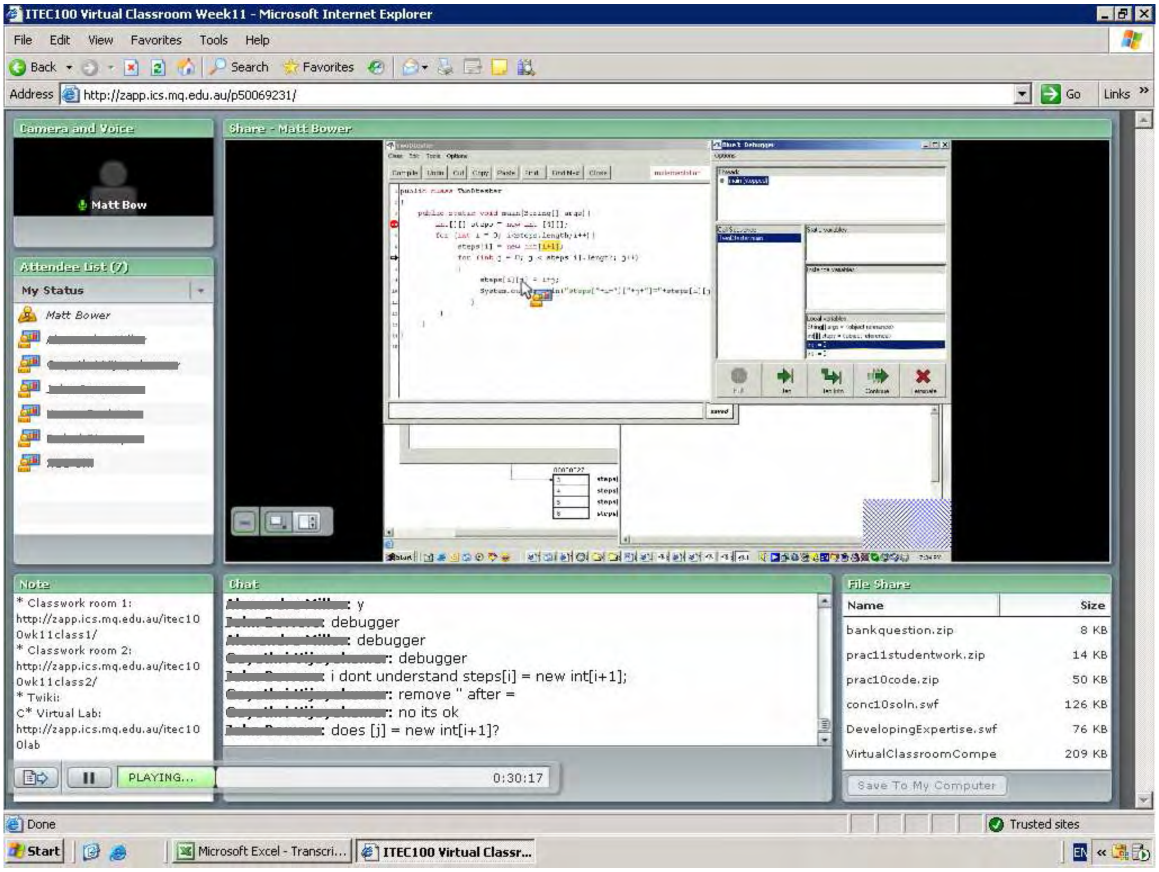


Figure 150 – Interface for episode in Topic 11 Iteration 2

Summary of episode:
The episode began with the teacher presenting a diagram of the solution submitted by a student as part of their pre-class exercises. The teacher then asked if students would like to see the code walked through on the debugger, to which students respond affirmatively. Thus the teacher broadcasts their IDE (see Figure 150). However the screen-share broadcasting of the code being executed line by line in the IDE was sub-optimal – firstly the teacher spent over 3 minutes adjusting the code so that it produced appropriate printouts to the terminal window, and then realized that the debugger did not show the actual array being formed. This resulted in a confusing delivery.

In this learning episode all 59 teacher textual discourse contributions were made via audio (ref. Table 32). As well, the teacher performed 37 modelling programming actions as they attempt to step through the program on the debugger (ref. Table 32). There were several other actions recorded, including seven instances of highlighting specific lines of program text with the cursor to focus students' attention upon it and switching from document sharing of the static solution to screen-sharing the IDE (ref. Table 32).

Students made 12 textual discourse contributions throughout the learning episode, all using text-chat (ref. Table 33). These were either Content based or Activity based (ref. Table 78). Of the 59 teacher textual discourse contributions, 48 are Content (ref. Table 77). However the teacher posed no questions about Content, with all textual discourse contributions being Statements (34 Independent, 1 Response to Question, 13 Response to Statement, ref. Table 77). This should be noted in tandem with the low level of student discourse.

The teacher attempted to use the resources at hand to clearly explain how the arrays were formed, but the presentation was unpractised and the teacher sensed it was unclear. The episode was cut short with the statement "What about just because I don't want to waste too much time on it, why don't you have a think about it and ask specific questions about it after you've had a look at that code and maybe run through it in the debugger and also had a look at that diagram". At the end of the lesson student misunderstanding is confirmed, with one of the most capable students in the class commenting that "my fuzz detector is buzzing crazily".

Even though the teacher has tried to demonstrate the formation of the two-dimensional arrays the presentation was unclear and did not provide students with the opportunity to apprehend the discourse, interpret forms of representation, act upon descriptions of the scenario, use feedback or reflect on the learning cycle (the events that Laurillard, 2002, deems critical for learning in tertiary environments). As in Iteration 1, the teacher has no means of assessing the level of understanding that students have developed.

T11_2006S1	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	0	34	0	0	1	13	0	0	48
Activity	0	2	0	0	0	3	0	0	5
Technology	0	0	0	0	0	0	0	0	0
Activity-Content	1	0	1	0	1	1	0	0	4
Activity-Technology	0	0	0	0	0	0	0	0	0
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	0	1	0	0	0	0	0	0	1
Unrelated/Unclassifiable	0	1	0	0	0	0	0	0	1
Totals	1	38	1	0	2	17	0	0	59

Table 77 – Topic 11 Iteration 2 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T11_2006S1	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	**Totals**
Content	0	4	0	1	1	0	0	0	**6**
Activity	0	0	0	0	4	1	0	0	**5**
Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content	1	0	0	0	0	0	0	0	**1**
Activity-Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	0	0	0	0	0	0	0	**0**
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	**0**
Totals	**1**	**4**	**0**	**1**	**5**	**1**	**0**	**0**	**12**

Table 78 – Topic 11 Iteration 2 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Learning Episode 21 (Topic 11 – Iteration 3)

Activity Design: Teacher-Led Whiteboard
Interface Design: Collaborative
Number of students: 2
Duration: 27.75 minutes

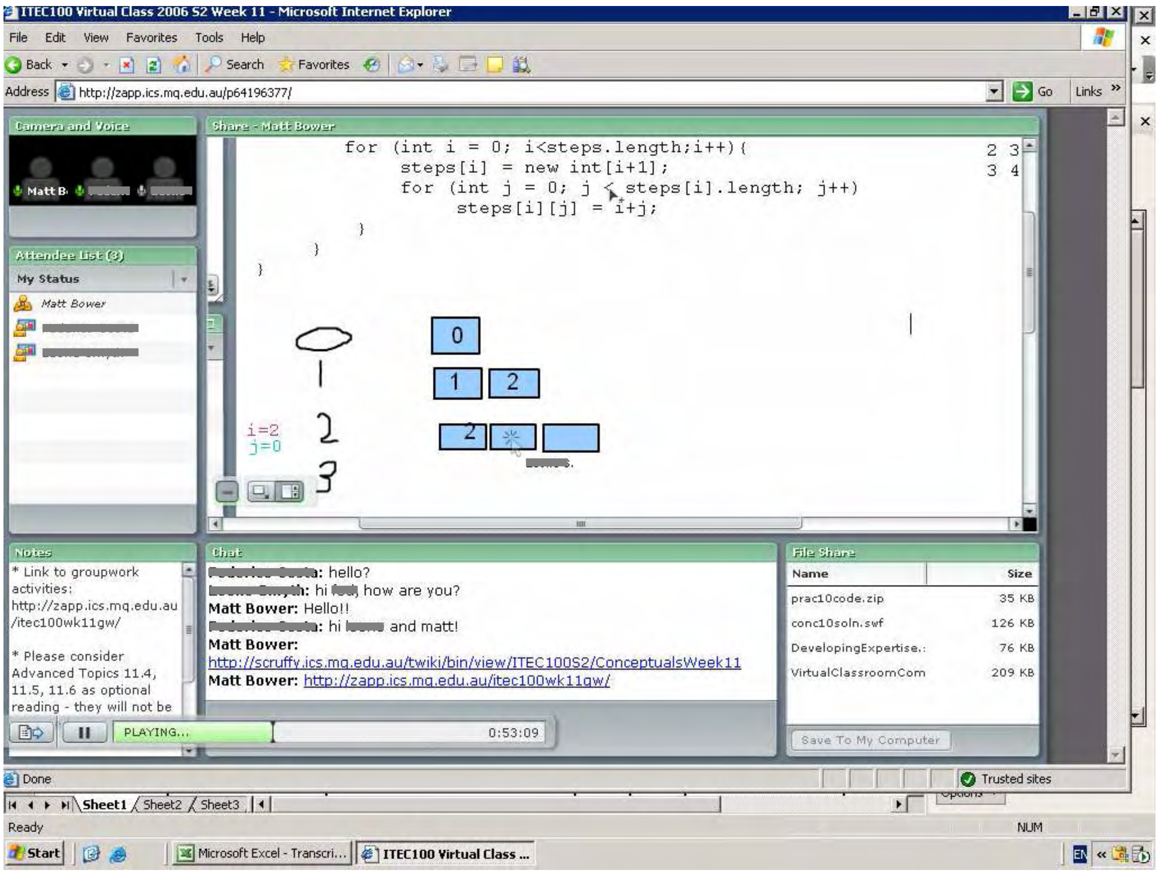


Figure 151 – Interface for episode in Topic 11 Iteration 3

Summary of episode:
After introducing the question and broadcasting a student solution, the teacher spent approximately seven minutes demonstrating how to adjust the program using the IDE so that it printed out the solution. Unlike Iteration 2 the debugger component of the IDE was not used (because the teacher now knows that it does not show the elements in the array). The class then spent approximately 12 minutes using the whiteboard as a shared workspace to emulate the operations of the computer as it would run the program (see Figure 151 for the interface layout). This led to clarification of the concept being affirmed by both students, including one student commenting during the whiteboard activity "Ah yeah ok I get it!".

The teacher took an active role in this lesson, making 234 audio based textual discourse contributions during this 27.75 episode. This is a greater rate of textual discourse contribution than observed in Iteration 1 and Iteration 2 despite the fact that there was more student discourse (30 in 4.5 minutes for Iteration 1, 59 in 10.5 minutes in Iteration 2, ref. Table 32). The teacher also performed a range of actions related to managing the learning episode, including copying and pasting programming code and solutions between windows, and changing layouts between broadcasting solution documents, screen-sharing and the whiteboard (ref. Table 32). He was also involved in the whiteboard activity with the students, performing 17 whiteboard related actions (ref. Table 32).

Students are slow to start on this task because the way in which they are meant to represent the program on the whiteboard was loosely defined. However overall students played a more active role in this iteration of the learning task than the previous two Iterations, performing 17 whiteboard operations and making 57 audio based textual discourse contributions (ref. Table 33). This indicates that the whiteboard space was truly shared with the teacher, afforded by the capacity for multi-person concurrent contribution. Of the 34 Content textual contributions 27 were Statement Responses (ref. Table 80). These are explained by the question-response approach being adopted by the teacher, prompting students to demonstrate the logic of the virtual machine on the whiteboard.

Of the 235 teacher textual discourse contributions, 157 were Content related (ref. Table 79). Of those 157 comments 40 are responsive, indicating a degree of interaction under this approach (ref. Table 79). Sixty-seven teacher comments were activity related (22 Activity, 30 Activity-Content, 12 Activity-Technology, 3 Activity-Content-Technology, ref. Table 79). These were due to the coordinating role that the teacher assumes during the whiteboard activity.

On occasions the teacher proposed approaches to representing concepts using the technology. For instance, the teacher's Activity-Content-Technology statement "Actually, what I might suggest and I don't want to take over it, but what I was thinking is we could represent arrays' elements as little boxes like that" provided students with guidance on using the technology to construct their semiotic representations, allowing them to more efficiently collaborate about the task.

This Iteration took 27.75 minutes, which is far longer than either Iteration 1 (4.5 minutes) or Iteration 2 (10.5 minutes). However the longer learning episode is not an indication of ineffectiveness, but rather a reflection of the depth with which the concepts were being addressed. Only when time was spent using the whiteboard as a distributed cognitive tool did students indicate clarification of understanding. Having students update the state of variables on the whiteboard and produce the output of the program manifest deep discussion (particularly of students' "notional machine", du Boulay, O'Shea, & Monk, 1989). This allowed the teacher to identify points at which student conceptions were weakly formed and offer appropriate remediation.

The whiteboard allowed for cognitive load to be managed (by storing variable values), prevented split attention (by having the program code, the solution and the students' working in the one area) and provided space for a shared mental model to be represented. The whiteboard enabled aspects of Laurillard's (2002) Conversational Framework by offering students the opportunity to apprehend the form of representation and then consolidate their mental models by applying those semiotic representations. The approach affords distributed cognition (Hollan, Hutchins, & Kirsh, 2000) – by using the web-conferencing system as a collaborative "mindtool" (Jonassen, 2000) a shared understanding is formed.

T11_2006S2	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	16	105	0	0	7	26	0	3	157
Activity	3	11	1	1	1	3	0	2	22
Technology	0	0	0	0	1	0	0	0	1
Activity-Content	9	14	0	0	2	3	0	2	30
Activity-Technology	0	11	0	0	1	0	0	0	12
Activity-Content-Tech.	0	2	0	0	1	0	0	0	3
Content-Technology	0	2	0	0	1	0	0	0	3
Task sentiments/attitudes	0	5	0	0	0	1	0	0	6
Unrelated/Unclassifiable	0	1	0	0	0	0	0	0	1
Totals	28	151	1	1	14	33	0	7	235

Table 79 – Topic 11 Iteration 3 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T11_2006S2	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	2	1	2	2	18	9	0	0	34
Activity	0	2	0	3	1	1	0	0	7
Technology	2	0	0	0	1	0	0	0	3
Activity-Content	0	1	0	0	2	0	0	0	3
Activity-Technology	1	1	0	0	0	0	0	0	2
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	1	0	0	0	0	0	1
Task sentiments/attitudes	0	4	0	0	1	0	0	0	5
Unrelated/Unclassifiable	0	1	0	0	0	1	0	0	2
Totals	5	10	3	5	23	11	0	0	57

Table 80 – Topic 11 Iteration 3 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Task 8 – "Adjust FileReader" (Topic 12)

Learning Task Analyzed: Meet a design specification (Procedural)

Question:
Here is a simple program to read information from a file called "input.txt" and write it to the terminal window. Change the program so that every full stop '.' that is contained in "input.txt" is converted to an exclamation mark '!' when the text is printed to the terminal window. Note that the "input.txt" file must be placed in the same directory as your class file.

```
import java.io.IOException;
import java.io.FileReader;
/**
 * Reads input from a file and writes it to the terminal window.
 */

public class Regurgitator
{
    public static void main(String[] args)
    {
        try
        {
            FileReader reader = new FileReader("input.txt");
            int next;
            char c;
            boolean done = false;
            while(!done)
            {
                next = reader.read();
                if (next == -1) done = true;
                else
                {
                    c = (char)next;
                    System.out.print(c);
                }
            }
            reader.close();
        }
        catch (IOException exception)
        {
            System.out.println("Error   in   processing   file:   "   +
exception);
        }
    }
}
```

Approaches:
In Iteration 1 the teacher asks students to suggest their solutions via text-chat (teacher-led) and the teacher makes the changes in the IDE. In Iteration 2 a communal whiteboard is used to compare and contrast several lines of different students' code at once (teacher-led whiteboard). In Iteration 3 students directly adjust the code in a note-pod as a group (student-centred note-pod).

Learning Episode 22 (Topic 12 – Iteration 1)

Activity Design: Teacher-Centred Presentation
Interface Design: Presentational
Number of students: 9
Duration: 5 minutes

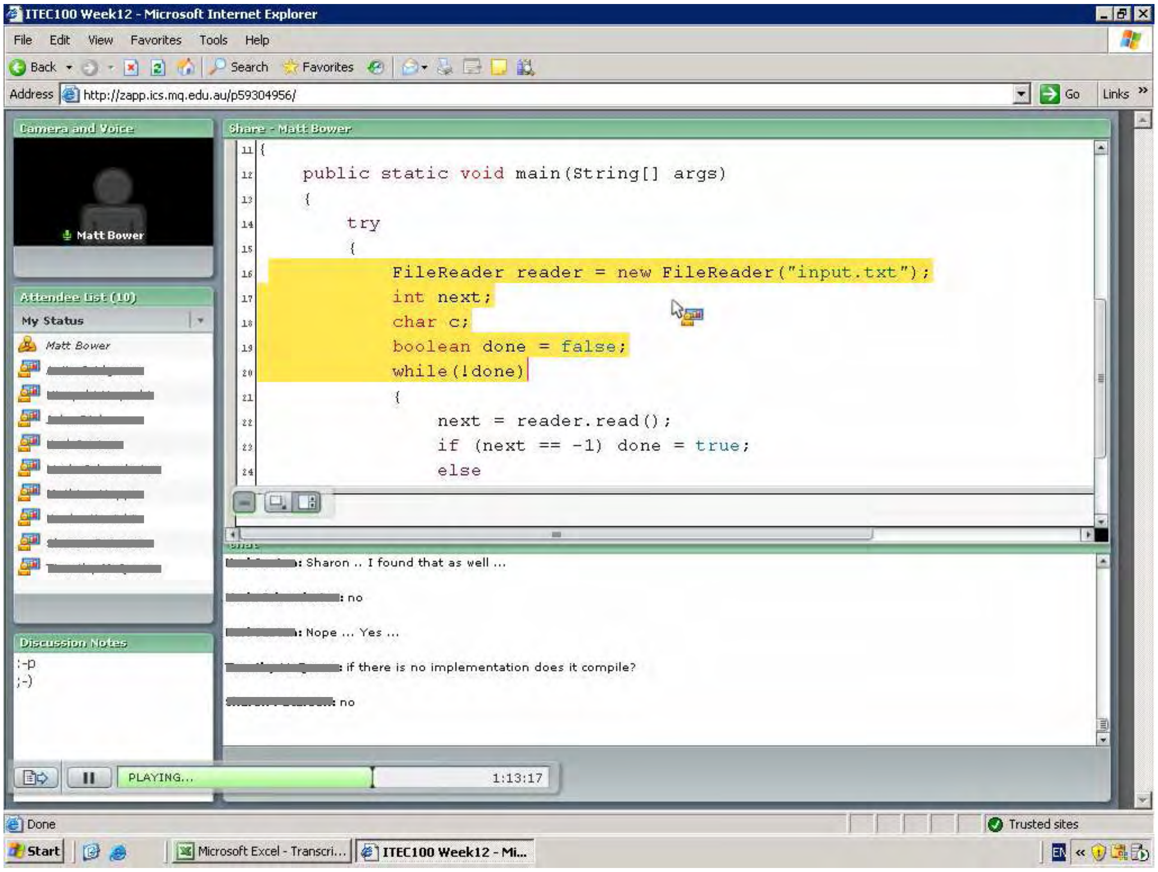


Figure 152 – Interface for episode in Topic 12 Iteration 1

Summary of episode:
In Iteration 1 of this task the teacher broadcasted their screen showing the program solution in the IDE. Once again the standard screen-sharing interface with the text-chat pod stretched across the bottom of the screen is being used (see Figure 152). The teacher used audio to explain the program line by line, often highlighting the lines of text that he was discussing to emphasize them (31 instances, ref. Table 32). The program was run and the terminal window output was displayed. The teacher then opened the original file which demonstrated its location and the fact that it contained full-stops and not exclamation marks (hence validating the program did indeed make the required changes).

Students only made four textual discourse contributions throughout the entire episode (all via the text-chat pod, ref. Table 33). These were all contributed in the last 15 seconds of the learning episode in response to the teacher's enquiry as to whether there are any questions (to which they respond in the negative).

The teacher's actions consisted of 34 textual discourse contributions made using audio, 8 screen-share modelling programming actions, and 31 highlighting text with the cursor actions (ref. Table 32). Of the 34 textual discourse contributions, 25 were Content Independent Statements (ref. Table 81). None of the teachers' textual discourse was responsive, an indication of the transmission approach to instruction that was adopted (ref. Table 81).

Even though the interface was suitable for the task and the content was authentic and meaningful, the teacher-centred activity design that was implemented inhibited student participation and thus prevented the teacher from being able to assess the level of student understanding.

T12_2005S2	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	0	25	0	0	0	0	0	0	25
Activity	1	2	0	0	0	0	0	0	3
Technology	0	0	0	0	0	0	0	0	0
Activity-Content	3	2	0	0	0	0	0	0	5
Activity-Technology	0	0	0	0	0	0	0	0	0
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	0	1	0	0	0	0	0	0	1
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	0
Totals	4	30	0	0	0	0	0	0	34

Table 81 – Topic 12 Iteration 1 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T12_2005S2	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	**Totals**
Content	0	0	0	0	3	0	0	0	**3**
Activity	0	0	0	0	1	0	0	0	**1**
Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content	0	0	0	0	0	0	0	0	**0**
Activity-Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	0	0	0	0	0	0	0	**0**
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	**0**
Totals	**0**	**0**	**0**	**0**	**4**	**0**	**0**	**0**	**4**

Table 82 – Topic 12 Iteration 1 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Learning Episode 23 (Topic 12 – Iteration 2)

Activity Design: Teacher-Led Whiteboard
Interface Design: Collaborative
Number of students: 7
Duration: 11.5 minutes

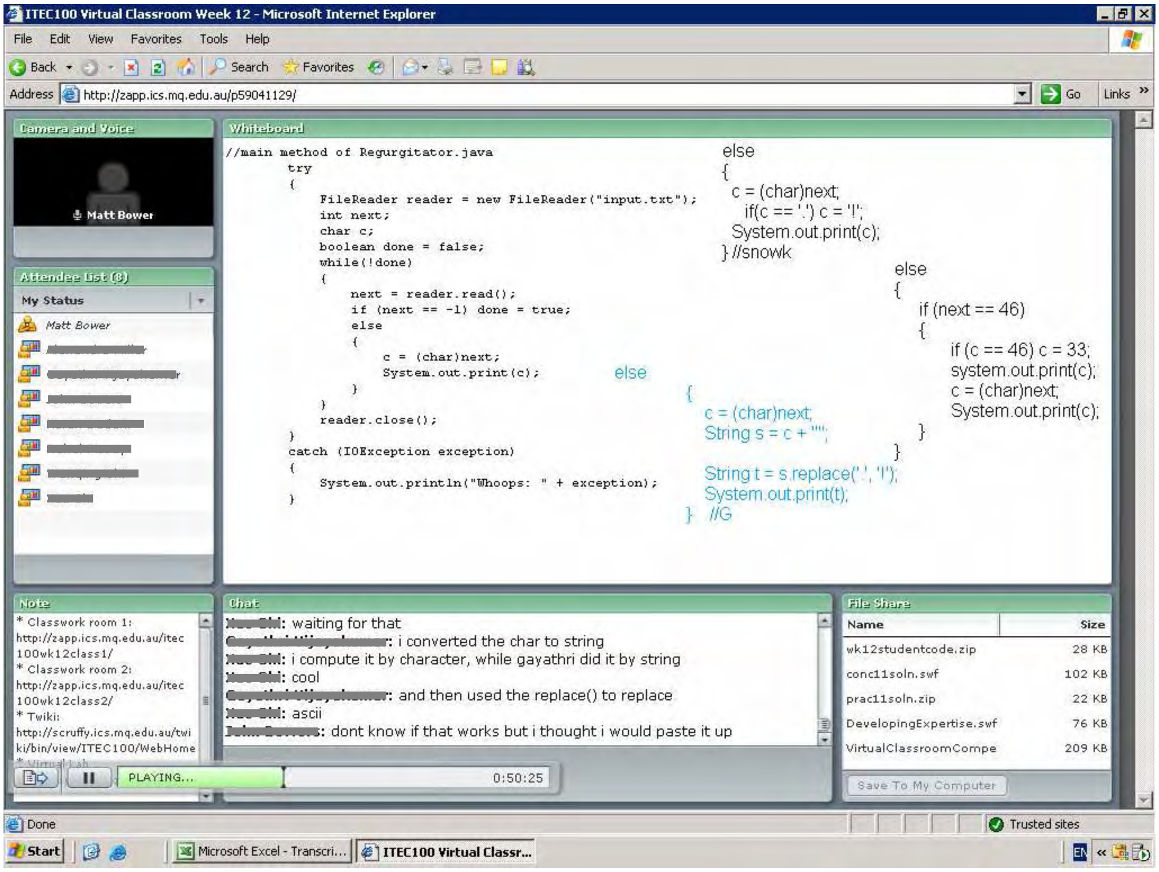


Figure 153 – Interface for episode in Topic 12 Iteration 2

Summary of episode:
For this Iteration of the task a whiteboard containing the program question was displayed in the major pod (see Figure 153). Students were asked to paste their 'else' loop solution into the whiteboard, and three students did so over a period of two and a half minutes. The interface design allowed students to compare and contrast solutions without splitting their attention between several files or different windows. Note that the whiteboard afforded the spatial flexibility to place contributions wherever desired, providing the potential for location to be used to relate pieces of information. All of the code was able to be placed in the one physical space as opposed to being split between files. As well, colour and font were used to distinguish or 'highlight' contributions (Mayer, 2005b). A trade-off against these affordance advantages is that contributions may be slower because more effort is required to select and

use the whiteboard tools and because students have additional decisions regarding the style and location of contribution.

The teacher asked students several questions about the program and solutions, in order to prompt student discussion. In the last 3 minutes of the learning episode the teacher broadcasted their IDE containing a student's solution. The teacher briefly discussed the critical lines and highlights those lines with the cursor to emphasize them. As in Iteration 1, the underlying file being read was open and its content is compared to the program output so that students could validate that the full stops had in fact been changed to exclamation marks.

The teacher made 90 textual discourse contributions using audio and 2 using text-chat (ref. Table 32). There were also nine modelling programming actions associated with running the solution program (ref. Table 32). The teacher also used the cursor to highlight critical portions of the program being discussed, which was less than in Iteration 1 when the strategy was used 31 times across the entire program (ref. Table 32).

Of the teacher's 92 textual discourse contributions, 50 were Content comments and 31 were Activity or Activity-related comments (ref. Table 84). The majority of the teacher's contributions were instructive, with 77 of the 92 teacher textual discourse contributions being Independent (13 Independent Questions, 64 Independent Statements, ref. Table 84). However 15 of the 31 student textual discourse contributions were Independent (ref. Table 84), indicating a degree of student empowerment and interest in the authentic task. As well, students contributed 21 Content statements including two that were Independent Questions (ref. Table 84). This demonstrates that students had the opportunity to discuss the subject matter and ask questions.

Through students' representations on the whiteboard and their corresponding discussion their mental models were revealed. Student text-chat evaluative comments included:

> GV: i converted the char to string
>
> XS: i compute it by character, while GV did it by string
>
> XS: think replace mine clause with JB's number formula, it will be a good one
>
> JB: we should create two constants [like] private static final ASCII_FULLSTOP = 46;

They were able to discuss the advantages and disadvantages of the various approaches presented, supporting abstraction and appreciation of good programming technique.

T12_2006S1	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Respong to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	8	37	0	1	0	3	0	1	50
Activity	2	10	0	0	1	1	0	1	15
Technology	0	0	0	0	0	0	0	0	0
Activity-Content	3	6	0	0	0	1	0	1	11
Activity-Technology	0	5	0	0	0	0	0	0	5
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	0	4	0	0	0	2	0	3	9
Unrelated/Unclassifiable	0	2	0	0	0	0	0	0	2
Totals	13	64	0	1	1	7	0	6	92

Table 83 – Topic 12 Iteration 2 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T12_2006S1	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	2	7	0	0	10	2	0	0	21
Activity	2	0	0	0	0	1	0	0	3
Technology	0	0	0	0	0	0	0	0	0
Activity-Content	0	3	0	0	1	0	0	0	4
Activity-Technology	0	0	0	0	0	0	0	0	0
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	0	1	0	0	0	2	0	0	3
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	0
Totals	4	11	0	0	11	5	0	0	31

Table 84 – Topic 12 Iteration 2 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Learning Episode 24 (Topic 12 – Iteration 3)

Activity Design: Group programming
Interface Design: Collaborative
Number of students: 3
Duration: 6.75 minutes

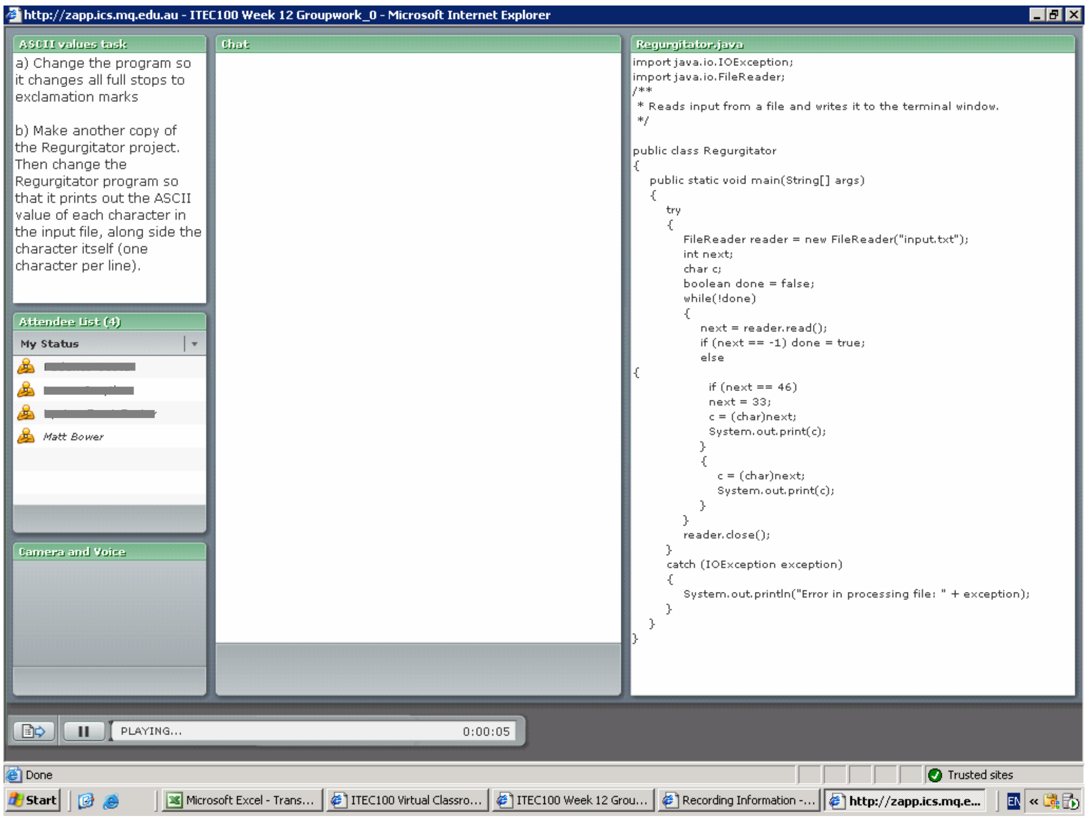


Figure 154 – Interface for episode in Topic 12 Iteration 3

Summary of episode:
This iteration the learning activity was attempted in a purpose designed group-work room that contained the program in the right hand note-pod and a text-chat area as a middle column of the interface (Figure 154). The question appeared in a small note-pod in the top-left corner of the room. There was only one student action during this episode (ref. Table 33) which consisted of inserting the code into the program on the note-pod to achieve the solution. With such a small contribution required for the solution, it is questionable whether moving students into a separate room with an entirely different interface was warranted. As well, the inclusion of the large text-chat area in the middle column of the screen was redundant, since students were using audio.

The teacher made 53 textual discourse contributions using audio and one text-chat comment (ref. Table 32). Once again, the teacher also broadcasted their screen to show the solution program run in the IDE, resulting in four modelling programming actions (ref. Table 32). In contrast to previous iterations the program was run and the original file was compared to the output before the teacher explained the core of how the program worked. No material difference in the quality of the explanation due to this change in sequencing was observed.

The techno-pedagogical tactic of using the cursor to highlight the program text being discussed was used 14 times by the teacher (ref. Table 32). The teachers' textual discourse contributions were verging on a teacher-centred approach, with 32 of 54 contributions being Content, and 44 of 54 being Independent comments (ref. Table 85). Students only made eight textual discourse contributions in the 6.75 minute learning episode, of which five were Content Statement Response to Question comments (ref. Table 86). Even though the interface has been designed for collaboration and the activity which students needed to complete required their involvement, the fact that the teacher dominated communication appeared to reduce the amount of student participation.

Unbeknownst to everyone else in the lesson one student was unable to make contributions because her display was locked on full screen. This meant she was unable to press the microphone button to use audio. The occurrence of such a critical technological problem in the last lesson of Iteration 3 demonstrates that while technological skills can be acquired quickly, it is possible for technological competencies to hinder collaboration and learning even after a teacher has four semesters of experience with the web-conferencing system.

T12_2006S2	Independent Question	Independent Statement	Question response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	2	24	0	4	0	2	0	0	32
Activity	1	6	0	0	0	1	0	0	8
Technology	0	0	0	0	0	0	0	0	0
Activity-Content	4	2	0	0	0	1	0	0	7
Activity-Technology	0	4	0	0	0	0	0	1	5
Activity-Content-Tech.	0	0	0	0	0	0	0	0	0
Content-Technology	0	0	0	0	0	0	0	0	0
Task sentiments/attitudes	0	0	0	0	0	1	0	0	1
Unrelated/Unclassifiable	0	1	0	0	0	0	0	0	1
Totals	7	37	0	4	0	5	0	1	54

Table 85 – Topic 12 Iteration 3 Subject-Interaction Counts for TEACHER textual discourse during learning episode

T12_2006S2	Independent Question	Independent Statement	Question Response to Question	Question Response to Statement	Statement Response to Question	Statement Response to Statement	Question Response to Action	Statement Response to Action	Totals
Content	0	0	0	0	5	0	0	0	**5**
Activity	0	2	0	0	0	0	0	0	**2**
Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content	0	0	0	0	0	0	0	0	**0**
Activity-Technology	0	0	0	0	0	0	0	0	**0**
Activity-Content-Tech.	0	0	0	0	0	0	0	0	**0**
Content-Technology	0	0	0	0	0	0	0	0	**0**
Task sentiments/attitudes	0	0	0	0	1	0	0	0	**1**
Unrelated/Unclassifiable	0	0	0	0	0	0	0	0	**0**
Totals	**0**	**2**	**0**	**0**	**6**	**0**	**0**	**0**	**8**

Table 86 – Topic 12 Iteration 3 Subject-Interaction Counts for STUDENT textual discourse during learning episode

Appendix B Part B – Limitations of Dataset

This part of the Appendix discusses limitations of the dataset in terms of two recording problems.

Firstly, due to a problem with the recording of the group 2 programming activity for Topic 3 it was not possible to transcribe the contributions made by the student to the IDE. However, the teacher observed half of this learning episode and was able to ascertain the approach adopted. As well, the text-chat discourse and the initial program were recorded which were directly incorporated into the transcription. The final transcription was then presented to the student who had operated the IDE for group 2, and he validated that the transcript accurately matched his recollection of the learning episode.

Only text-chat contributions that were necessarily and directly implied by the program writing activity and the text-chat conversations were included in the transcript. Thus the nine textual discourse contributions that resulted from the reconstruction of the student's text-chat contributions may under-represent the number that the student made, however they serve to accurately represent the nature of activity and interaction in this learning episode. It is estimated at most there could have been up to another six textual discourse contributions posted through the screen-share, however since this maximum error represents less than 4% of the total student textual discourse in this learning episode and less than 0.16% of textual discourse across all learning episodes this was not considered a critical matter to this study. As well, statistical comparison and contrast between the group-work rooms has been avoided so as not to draw conclusions from any potential error contained in these results.

Secondly, the shallow versus deep copy whiteboard activity of Topic 9 Iteration 3 was not recorded at the time of teaching. In order to represent the nature of collaboration for the interface and learning design that was adopted, previous semesters' students were asked to volunteer to attempt the activity in order to provide a substitute recording. This was then transcribed and used in place of the missing recording. While the recording that was used may not be identical to the actual collaborations that occurred during the lesson, it does represent collaborations within the variance that may occur if any of the learning episodes were attempted again. That is to say, it cannot be assumed that the actual lessons that were conducted are the only collaborations that could have occurred under a particular interface or learning design – a degree of variation between identical implementations should always be expected. Since the interface and learning design adopted in the replacement episode were identical the approach to accounting for the missing data can be considered within the range of normal variation.

Appendix B Part C – Statistical Tests

This part of the Appendix contains details of all statistical tests that have been referenced throughout this report.

Statistical Test 1

H_0: There is *no* difference in the proportion of different types of teacher textual discourse for the three iterations in Topic 1.
H_1: There is a difference in the proportion of different types of teacher textual discourse for the three iterations in Topic 1.

TEACHER OBSERVED	Content Independent Question	Content Independent Statement	Content Statement Response	OTHER CONTENT	OTHER	Total
Topic 1 Iteration 1	5	22	14	10	17	**68**
Topic 1 Iteration 2	5	24	13	4	14	**60**
Topic 1 Iteration 3	11	31	17	3	14	**76**
Total	**21**	**77**	**44**	**17**	**45**	**204**

Table 87 – Observed Teacher textual discourse contributions for Topic 1

Results of Chi-square analysis of observed versus expected proportions:

$\chi^2 = 8.964$
d.f. = 8
p-value = 0.345 (not significant).

Statistical Test 2

H_0: There is *no* difference in the proportion of different types of student textual discourse for the three iterations in Topic 1.
H_1: There is a difference in the proportion of different types of student textual discourse for the three iterations in Topic 1.

STUDENT OBSERVED	Content Statement Response	OTHER CONTENT	OTHER	Total
Topic 1 Iteration 1	15	5	7	**27**
Topic 1 Iteration 2	15	4	3	**22**
Topic 1 Iteration 3	14	6	6	**26**
Total	**44**	**15**	**16**	**75**

Table 88 – Observed student textual discourse contributions for Topic 1

Results of Chi-square analysis of observed versus expected proportions:

$\chi^2 = 1.591$
d.f. = 4
p-value = 0.810 (not significant).

Statistical Test 3

H_0: There is *no* difference in the proportions of teacher Subject textual discourse between Topic 3 Iteration 1 and Iteration 2.
H_1: There is a difference in the proportions of teacher Subject textual discourse between Topic 3 Iteration 1 and Iteration 2.

TEACHER OBSERVED	Content	Activity	Activity-Content	Activity-Technology	ALL OTHER	Total
Iteration 1	118	14	8	4	13	**157**
Iteration 2	32	42	9	39	17	**139**
Totals	**150**	**56**	**17**	**43**	**30**	**296**

Table 89 – Observed teacher Subject textual discourse Topic 3 Iteration 1 and Iteration 2

Results of Chi-square analysis of observed versus expected proportions:

$\chi^2 = 91.6$
d.f. = 4
p-value < 0.0001 (highly significant).

The results of testing for difference between each of the teacher Subject type proportions for the two Iterations using 2x2 Chi-square analysis is represented in the following table:

	Content	Activity	Activity-Content	Activity-Technology	ALL OTHER
Chi Square value	80.18	21.80	0.26	38.64	1.26
p-value (d.f. = 1)	0.0000	0.0000	0.6107	0.0000	0.2611

Table 90 – Chi-square and p-values for tests of difference between proportion of teacher Subject types in Iteration 1 and Iteration 2

Note: Based on an overall significance level of 5% a Bonferroni adjusted significance level of 0.05/5 = 0.01 or 1% has been adopted for individual tests in the table above.

Statistical Test 4

H_0: There is *no* difference in the proportions of teacher textual discourse Interactions between Topic 3 Iteration 1 and Iteration 2.
H_1: There is a difference in the proportions of teacher textual discourse Interactions between Topic 3 Iteration 1 and Iteration 2.

TEACHER OBSERVED	Independ. Question	Independ. Statement	Statement Resp. to Question	Statement Resp. to Statement	Statement Resp. to Action	OTHER INTERACTION	Totals
Iteration 1	25	76	17	31	7	1	**157**
Iteration 2	8	83	5	18	25	0	**139**
Totals	**33**	**159**	**22**	**49**	**32**	**1**	**296**

Table 91 – Observed teacher Interaction textual discourse Topic 3 Iteration 1 and Iteration 2

Results of Chi-square analysis of observed versus expected proportions:

$\chi^2 = 29.2$

d.f. = 5

p-value < 0.0001 (highly significant).

The results of testing for difference between each of the teacher Interaction type proportions for the two Iterations using 2x2 Chi-square analysis is represented in the following table:

	Independ. Question	Independ. Statement	Statement Resp. to Question	Statement Resp. to Statement	Statement Resp. to Action	OTHER INTERACTION
Chi Squared value	7.70	3.79	5.60	2.46	13.99	0.89
p-value (d.f. = 1)	0.0055	0.0516	0.0179	0.1164	0.0002	0.3459

Table 92 – Chi-square and p-values for tests of difference between proportion of teacher Interaction types in Iteration 1 and Iteration 2

Note: Based on an overall significance level of 5% a Bonferroni adjusted significance level of 0.05/6 = 0.0086 or 0.866% has been adopted for individual tests in the table above.

Statistical Test 5

H_0: There is *no* difference in the proportions of student Subject textual discourse between Topic 3 Iteration 1 and Iteration 2.

H_1: There is a difference in the proportions of student Subject textual discourse between Topic 3 Iteration 1 and Iteration 2.

STUDENT OBSERVED	**Content**	**Activity**	**Activity-Content**	**Activity-Technology**	**ALL OTHER**	**Total**
Iteration 1	43	0	0	0	1	**44**
Iteration 2	74	29	25	10	16	**154**
Totals	**117**	**29**	**25**	**10**	**17**	**198**

Table 93 – Observed student Subject textual discourse Topic 3 Iteration 1 and Iteration 2

Results of Chi-square analysis of observed versus expected proportions:

$\chi^2 = 35.2$

d.f. = 4

p-value < 0.0001 (highly significant).

The results of testing for difference between each of the student Subject type proportions for the two Iterations using 2x2 Chi-square analysis is represented in the following table:

	Content	**Activity**	**Activity-Content**	**Activity-Technology**	**ALL OTHER**
Chi Squared value	34.93	9.71	8.18	3.01	2.87
p-value (d.f. = 1)	0.0000	0.0018	0.0042	0.0828	0.0901

Table 94 – Chi-square and p-values for tests of difference between proportion of student Subject types in Iteration 1 and Iteration 2

Note: Based on an overall significance level of 5% a Bonferroni adjusted significance level of 0.05/5 = 0.01 or 1% has been adopted for individual tests in the table above.

Statistical Test 6

H_0: There is *no* difference in the proportions of student textual discourse Interactions between Topic 3 Iteration 1 and Iteration 2.
H_1: There is a difference in the proportions of student textual discourse Interactions between Topic 3 Iteration 1 and Iteration 2.

STUDENT OBSERVED	Independent Question	Independent Statement	Statement Response to Question	Statement Response to Statement	Statement Response to Action	OTHER INTERACTION	Totals
Iteration 1	1	1	37	2	0	3	**44**
Iteration 2	21	54	38	18	15	8	**154**
Totals	**22**	**55**	**75**	**20**	**15**	**11**	**198**

Table 95 – Observed student Interaction textual discourse Topic 3 Iteration 1 and Iteration 2

Results of Chi-square analysis of observed versus expected proportions:

$\chi^2 = 55.3$
d.f. = 5
p-value < 0.0001 (highly significant).

The results of testing for difference between each of the student Interaction type proportions for the two Iterations using 2x2 Chi-square analysis is represented in the following table:

	Independent Question	**Independent Statement**	**Statement Response to Question**	**Statement Response to Statement**	**Statement Response to Action**	**OTHER INTERACTION**
Chi Squared value	4.47	18.34	51.34	1.92	4.64	0.17
p-value (d.f. = 1)	0.0344	0.0000	0.0000	0.1655	0.0313	0.6784

Table 96 – Chi-square and p-values for tests of difference between proportion of student Interaction types in Iteration 1 and Iteration 2

Note: Based on an overall significance level of 5% a Bonferroni adjusted significance level of 0.05/6 = 0.0086 or 0.866% has been adopted for individual tests in the table above.

Statistical Test 7

H_0: There is *no* difference in the proportions of teacher Subject textual discourse between Topic 3 Iteration 1 and Iteration 3.
H_1: There is a difference in the proportions of teacher Subject textual discourse between Topic 3 Iteration 1 and Iteration 3.

TEACHER OBSERVED	Content	Activity	Activity-Content	Activity-Technology	ALL OTHER	Total
Iteration 1	118	14	8	4	13	**157**
Iteration 3	126	16	8	13	15	**178**
Totals	**244**	**30**	**16**	**17**	**28**	**335**

Table 97 – Observed teacher Subject textual discourse Topic 3 Iteration 1 and Iteration 3

Results of Chi-square analysis of observed versus expected proportions:

$\chi^2 = 4.00$
d.f. = 4
p-value = 0.4057 (not significant).

Statistical Test 8

H_0: There is *no* difference in the proportions of teacher textual discourse Interactions between Topic 3 Iteration 1 and Iteration 3.
H_1: There is a difference in the proportions of teacher textual discourse Interactions between Topic 3 Iteration 1 and Iteration 3.

TEACHER OBSERVED	Independent Question	Independent Statement	Statement Response to Question	Statement Response to Statement	Statement Response to Action	OTHER INTERACTION	Totals
Iteration 1	25	76	17	31	7	1	**157**
Iteration 3	33	96	10	27	6	6	**178**
Totals	**58**	**172**	**27**	**58**	**13**	**7**	**335**

Table 98 – Observed teacher Interaction textual discourse Topic 3 Iteration 1 and Iteration 3

Results of Chi-square analysis of observed versus expected proportions:

$\chi^2 = 7.88$
d.f. = 5
p-value = 0.1628 (not significant).

Statistical Test 9

H_0: There is *no* difference in the proportions of student Subject textual discourse between Topic 3 Iteration 1 and Iteration 3.
H_1: There is a difference in the proportions of student Subject textual discourse between Topic 3 Iteration 1 and Iteration 3.

STUDENT OBSERVED	Content	Activity	Activity-Content	Activity-Technology	ALL OTHER	Total
Iteration 1	43	0	0	0	1	**44**
Iteration 3	31	2	2	9	4	**48**
Totals	**74**	**2**	**2**	**9**	**5**	**92**

Table 99 – Observed student Subject textual discourse Topic 3 Iteration 1 and Iteration 3

Results of Chi-square analysis of observed versus expected proportions:

$\chi^2 = 16.6$
d.f. = 4
p-value < 0.0023 (significant).

The results of testing for difference between each of the student Subject type proportions for the two Iterations using 2x2 Chi-square analysis is represented in the following table:

	Content	**Activity**	**Activity-Content**	**Activity-Technology**	**ALL OTHER**
Chi Squared value	**16.02**	**1.87**	**1.87**	**9.14**	**1.64**
p-value (d.f. = 1)	**0.0001**	**0.1710**	**0.1710**	**0.0025**	**0.2002**

Table 100 – Chi-square and p-values for tests of difference between proportion of student Subject types in Iteration 1 and Iteration 3

Note: Based on an overall significance level of 5% a Bonferroni adjusted significance level of 0.05/5 = 0.01 or 1% has been adopted for individual tests in the table above.

Statistical Test 10

H_0: There is *no* difference in the proportions of student textual discourse Interactions between Topic 3 Iteration 1 and Iteration 3.
H_1: There is a difference in the proportions of student textual discourse Interactions between Topic 3 Iteration 1 and Iteration 3.

STUDENT OBSERVED	Independ. Question	Independ. Statement	Statement Resp. to Question	Statement Resp. to Statement	Statement Resp. to Action	OTHER INTERACTION	Totals
Iteration 1	1	1	37	2	0	3	**44**
Iteration 3	3	3	27	3	2	10	**48**
Totals	**4**	**4**	**64**	**5**	**2**	**13**	**92**

Table 101 – Observed student Interaction textual discourse Topic 3 Iteration 1 and Iteration 3

Results of Chi-square analysis of observed versus expected proportions:

$\chi^2 = 9.38$
d.f. = 5
p-value < 0.0950 (not significant).

Statistical Test 11

H_0: There is *no* difference in the proportions of teacher Subject textual discourse between Topic 3 Iteration 2 and Iteration 3.
H_1: There is a difference in the proportions of teacher Subject textual discourse between Topic 3 Iteration 2 and Iteration 3.

TEACHER OBSERVED	Content	Activity	Activity-Content	Activity-Technology	ALL OTHER	Total
Iteration 2	32	42	9	39	17	**139**
Iteration 3	126	16	8	13	15	**178**
Totals	**158**	**58**	**17**	**52**	**32**	**317**

Table 102 – Observed teacher Subject textual discourse Topic 3 Iteration 2 and Iteration 3

Results of Chi-square analysis of observed versus expected proportions:

$\chi^2 = 77.1$
d.f. = 4
p-value < 0.0001 (highly significant).

The results of testing for difference between each of the teacher Subject type proportions for the two Iterations using 2x2 Chi-square analysis is represented in the following table:

	Content	Activity	Activity-Content	Activity-Technology	ALL OTHER
Chi Square value	71.23	23.53	0.60	24.52	1.24
p-value (d.f. = 1)	0.0000	0.0000	0.4374	0.0000	0.2647

Table 103 – Chi-square and p-values for tests of difference between proportion of teacher Subject types in Iteration 2 and Iteration 3

Note: Based on an overall significance level of 5% a Bonferroni adjusted significance level of 0.05/5 = 0.01 or 1% has been adopted for individual tests in the table above.

Statistical Test 12

H_0: There is *no* difference in the proportions of teacher textual discourse Interactions between Topic 3 Iteration 2 and Iteration 3.
H_1: There is a difference in the proportions of teacher textual discourse Interactions between Topic 3 Iteration 2 and Iteration 3.

TEACHER OBSERVED	Independent Question	Independent Statement	Statement Response to Question	Statement Response to Statement	Statement Response to Action	OTHER INTERACTION	Totals
Iteration 2	8	83	5	18	25	0	**139**
Iteration 3	33	96	10	27	6	6	**178**
Totals	**41**	**179**	**15**	**45**	**31**	**6**	**317**

Table 104 – Observed teacher Interaction textual discourse Topic 3 Iteration 2 and Iteration 3

Results of Chi-square analysis of observed versus expected proportions:

$\chi^2 = 33.0$
d.f. = 5
p-value < 0.0001 (highly significant).

The results of testing for difference between each of the teacher Interaction type proportions for the two Iterations using 2x2 Chi-square analysis is represented in the following table:

	Independent Question	Independent Statement	Statement Response to Question	Statement Response to Statement	Statement Response to Action	OTHER INTERACTION
Chi Square value	11.33	1.06	0.71	0.32	18.90	4.78
p-value (d.f. = 1)	0.0008	0.3031	0.4004	0.5743	0.0000	0.0289

Table 105 – Chi-square and p-values for tests of difference between proportion of teacher Interaction types in Iteration 2 and Iteration 3

Note: Based on an overall significance level of 5% a Bonferroni adjusted significance level of 0.05/6 = 0.0087 or 0.87% has been adopted for individual tests in the table above.

Statistical Test 13

H_0: There is *no* difference in the proportions of student Subject textual discourse between Topic 3 Iteration 2 and Iteration 3.
H_1: There is a difference in the proportions of student Subject textual discourse between Topic 3 Iteration 2 and Iteration 3.

STUDENT OBSERVED	Content	Activity	Activity-Content	Activity-Technology	ALL OTHER	Total
Iteration 2	74	29	25	10	16	**154**
Iteration 3	31	2	2	9	4	**48**
Totals	**105**	**31**	**27**	**19**	**20**	**202**

Table 106 – Observed student Subject textual discourse Topic 3 Iteration 2 and Iteration 3

Results of Chi-square analysis of observed versus expected proportions:

$\chi^2 = 17.0$
d.f. = 4
p-value = 0.0019 (significant).

The results of testing for difference between each of the student Subject type proportions for the two Iterations using 2x2 Chi-square analysis is represented in the following table:

	Content	Activity	Activity-Content	Activity-Technology	ALL OTHER
Chi Square value	4.01	6.06	4.60	6.45	0.17
p-value (d.f. = 1)	0.0453	0.0138	0.0319	0.0111	0.6771

Table 107 – Chi-square and p-values for tests of difference between proportion of student Subject types in Iteration 2 and Iteration 3

Note: Based on an overall significance level of 5% a Bonferroni adjusted significance level of 0.05/5 = 0.01 or 1% has been adopted for individual tests in the table above.

Statistical Test 14

H_0: There is *no* difference in the proportions of student textual discourse Interactions between Topic 3 Iteration 2 and Iteration 3.
H_1: There is a difference in the proportions of student textual discourse Interactions between Topic 3 Iteration 2 and Iteration 3.

STUDENT OBSERVED	Independent Question	Independent Statement	Statement Resp. to Question	Statement Resp. to Statement	Statement Resp. to Action	OTHER INTERACTION	Totals
Iteration 2	21	54	38	18	15	8	**154**
Iteration 3	3	3	27	3	2	10	**48**
Totals	**24**	**57**	**65**	**21**	**17**	**18**	**202**

Table 108 – Observed student Interaction textual discourse Topic 3 Iteration 2 and Iteration 3

Results of Chi-square analysis of observed versus expected proportions:

$\chi^2 = 36.2$
d.f. = 5
p-value < 0.0001 (highly significant).

The results of testing for difference between each of the student Interaction type proportions for the two Iterations using 2x2 Chi-square analysis is represented in the following table:

	Independent Question	**Independent Statement**	**Statement Response to Question**	**Statement Response to Statement**	**Statement Response to Action**	**OTHER INTERACTION**
Chi-square value	1.91	15.00	16.72	1.16	1.47	11.03
p-value (d.f. = 1)	0.1673	0.0001	0.0000	0.2811	0.2246	0.0009

Table 109 – Chi-square and p-values for tests of difference between proportion of student Interaction types in Iteration 1 and Iteration 2

Note: Based on an overall significance level of 5% a Bonferroni adjusted significance level of 0.05/6 = 0.0087 or 0.87% has been adopted for individual tests in the table above.

Statistical Test 15

H_0: There is *not* a different proportion of teacher content related textual discourse in Topic 9 Iteration 1 as opposed to Iteration 2.
H_1: There is a different proportion of teacher content related textual discourse in Topic 9 Iteration 1 as opposed to Iteration 2.

TEACHER OBSERVED	content related	non-content related	**Total**
Iteration 1	31	45	**76**
Iteration 2	28	15	**43**
Total	**59**	**60**	**119**

Table 110 – Observed teacher content related textual discourse Topic 9 Iteration 1 and Iteration 2

Results of Chi-square analysis of observed versus expected proportions:

$\chi^2 = 6.50$
d.f. = 1
p-value = 0.01078 (significant).

Statistical Test 16

H_0: There is *not* a different proportion of student Content textual discourse in Topic 10 Iteration 1 as opposed to Iteration 2.
H_1: There is a different proportion of student Content textual discourse in Topic 10 Iteration 1 as opposed to Iteration 2.

STUDENT OBSERVED	Content	Non-Content	**Total**
Iteration 1	36	28	**64**
Iteration 2	43	104	**147**
Total	**79**	**132**	**211**

Table 111 – Observed student Content textual discourse Topic 10 Iteration 1 and Iteration 2

Results of Chi-square analysis of observed versus expected proportions:

$\chi^2 = 13.9$
d.f. = 1
p-value = 0.0002 (highly significant).

Statistical Test 17

H_0: There is *no* significant difference between proportions of teacher versus student Subject textual discourse across all episodes.
H_1: There is a significant difference between proportions of teacher versus student Subject textual discourse across all episodes.

OBSERVED	Teacher	Student	**Total**
Content	1234	883	**2117**
Activity	354	286	**640**
Technology	22	15	**37**
Activity-Content	189	194	**383**
Activity-Technology	192	81	**273**
Activity-Content-Tech.	10	1	**11**
Content-Technology	6	1	**7**
Task sentiments / attitudes	177	68	**245**
Unrelated / Unclassifiable	57	55	**112**
Total	**2241**	**1584**	**3825**

Table 112 – Observed teacher and student textual discourse by Subject type across all episodes

Results of Chi-square analysis of observed versus expected proportions:

$\chi^2 = 60.3$
d.f. = 8
p-value < 0.00001 (highly significant).

Statistical Test 18

H_0: There is *no* significant difference between proportions of teacher versus student Interaction textual discourse across all episodes.
H_1: There is a significant difference between proportions of teacher versus student Interaction textual discourse across all episodes.

OBSERVED	Teacher	Student	Total
Independent Question	303	173	476
Independent Statement	1238	402	1640
Question response to Question	12	39	51
Question Response to Statement	40	68	108
Statement Response to Question	137	566	703
Statement Response to Statement	404	282	686
Question Response to Action	2	7	9
Statement Response to Action	105	47	152
Total	**2241**	**1584**	**3825**

Table 113 – Observed teacher and student textual discourse by Interaction type across all episodes

Results of Chi-square analysis of observed versus expected proportions:

$\chi^2 = 699$
d.f. = 7
p-value < 0.00001 (highly significant).

Statistical Test 19

H_0: Textual discourse per student per minute is *not* linearly correlated with teacher independent questions per minute.
H_1: Textual discourse per student per minute is linearly correlated with teacher independent questions per minute.

Correlation Statistics	
Multiple R	0.155863
R Square	0.024293
Adjusted R Square	-0.02006
Standard Error	0.554726
Observations	24

Table 114 – Correlation statistics for Textual Discourse per student per minute versus teacher Independent Questions per minute

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.835397	0.230767	3.620094	0.001516
$\hat{\beta}$	-0.15485	0.209229	-0.74011	0.467061

Table 115 – Regression statistics for Textual Discourse per student per minute versus teacher Independent Questions per minute

The $\hat{\beta}$ p-value = 0.467061 therefore no evidence to reject the null hypothesis using a 5% significance level.

Statistical Test 20

H_0: Textual discourse per student per minute is *not* linearly correlated with teacher independent questions per minute.
H_1: Textual discourse per student per minute is linearly correlated with teacher independent questions per minute.

Correlation Statistics	
Multiple R	0.501556
R Square	0.251558
Adjusted R Square	0.217538
Standard Error	0.17942
Observations	24

Table 116 – Correlation statistics for Responses to Questions per student per minute versus teacher Independent Questions per minute

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.141752	0.074639	1.899171	0.070733
X Variable 1	0.18402	0.067673	2.719264	0.012525

Table 117 – Regression statistics for Responses to Questions per student per minute versus teacher Independent Questions per minute

The $\hat{\beta}$ p-value = 0.012525, providing evidence to reject the null hypothesis using a 5% significance level.

Statistical Test 21

H_0: There is *no* difference in the rates of teacher textual discourse per minute between the Teacher-centred, Teacher-led and Student-centred activity designs.
H_1: There is a difference in the rates of teacher textual discourse per minute between the Teacher-centred, Teacher-led and Student-centred activity designs.

The rates of teacher textual discourse per minute for each of the 24 learning episodes (grouped by activity design) is provided in Table 118.

Teacher-centred	Teacher-led	Student-centred
6.468	9.714	3.486
4.914	9.600	8.109
6.667	7.238	7.316
5.619	10.207	3.420
6.800	8.486	6.429
	10.471	6.074
	8.800	4.275
	5.860	1.667
	8.468	
	7.8230	
	8.000	

Table 118 – Rates of teacher contribution per episode by activity design for the 24 learning episodes

The results of performing a one way analysis of variance (ANOVA) test on the above data are summarized in Table 119 below.

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	61.30096	2	30.65048	11.52237	0.000419	3.4668
Within Groups	55.86178	21	2.660085			
Total	117.1627	23				

Table 119 – Results of ANOVA analysis of teacher contributions per episode by activity type

The F-statistic has a p-value of 0.000419 which at a 5% significance level provides evidence to reject the null hypothesis.

Two tailed T-tests to determine source of differences:

TEACHER	T statistic	d.f.	p-value
Teacher-centred vs Teacher-led	-3.779	14	**0.0020**
Teacher-centred vs Student-centred	0.951	11	0.3619
Teacher-led vs Student-centred	4.267	17	**0.0005**

Table 120 – Results of T-tests for differences in teacher rates of textual discourse between activity designs

Note: Based on an overall significance level of 5% a Bonferroni adjusted significance level of 0.05/3 = 0.0167 or 1.67% has been adopted for individual tests in the table above. On this basis the above tests provide evidence to reject the hypotheses that the Teacher-Centred and Teacher-led rates of textual discourse are the same, as well as evidence to reject the hypotheses that the Teacher-led and Student-centred rates of textual discourse are the same.

Statistical Test 22

H_0: There is *no* difference in the rates of per-student textual discourse per minute between the Teacher-centred, Teacher-led and Student-centred activity designs.
H_1: There is a difference in the rates of per-student textual discourse per minute between the Teacher-centred, Teacher-led and Student-centred activity designs.

The rates of average per-student textual discourse per minute for each of the 24 learning episodes (grouped by activity design) is provided in Table 121.

Teacher-centred	Teacher-led	Student-centred
0.369	0.429	1.014
0.131	0.320	0.788
0.0247	1.238	0.901
0.190	0.603	1.674
0.089	0.297	1.000
	0.941	0.778
	0.444	0.641
	0.372	2.435
	1.027	
	0.377	
	0.395	

Table 121 – Rates of per-student contribution per episode by activity design for the 24 learning episodes

The results of performing a one way analysis of variance (ANOVA) test on the above data are summarized in Table 122 below.

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3.240731	2	1.620365	9.202444	0.001349	3.4668
Within Groups	3.697678	21	0.17608			
Total	6.938409	23				

Table 122 – Results of ANOVA analysis of per-student contributions per episode by activity type

The F-statistic has a p-value of 0.001349 which at a 5% significance level provides evidence to reject the null hypothesis.

Two tailed T-tests to determine source of differences:

PER-STUDENT	T statistic	d.f.	p-value
Teacher-centred vs Teacher-led	-2.762	14	**0.0153**
Teacher-centred vs Student-centred	-3.565	11	**0.0044**
Teacher-led vs Student-centred	-2.646	17	*0.0170*

Table 123 – Results of T-tests for differences in teacher rates of textual discourse between activity designs

Note: Based on an overall significance level of 5% a Bonferroni adjusted significance level of 0.05/3 = 0.0167 or 1.67% has been adopted for individual tests in the table above. On this basis the above tests provide evidence to reject the hypotheses that any of the per-student textual discourse rates for the different activity designs were the same. (Note that the Teacher-led versus Student-centred test is borderline and significant for a p-value and alpha value accurate to 3 decimal places, and thus has been scrutinized and discussed further in this analysis).

Statistical Test 23

H_0: There is *no* difference in the rates of teacher textual discourse per minute between the Teacher-centred, Teacher-led and Student-centred activity designs for each of the different Subject types.
H_1: There is a difference in the rates of teacher textual discourse per minute between the Teacher-centred, Teacher-Led and Student-centred activity designs for each of the different Subject types.

The test statistics and corresponding p-values from performing two-tailed Student T-tests for differences in teacher textual discourse contribution rates between activity designs by individual Subject types are represented in Table 124 and Table 125 below.

In order to improve the reliability of the analysis, only Subject types relating to learning with average rates of teacher textual discourse contribution per episode of 5 or greater (i.e. 120 contributions across the 24 learning episodes) were considered for analysis (that is Content, Activity, Activity-Content, and Activity-Technology, ref. Figure 48). As well, differences between rates for the Teacher-Centred and Student-centred were not considered on the basis that there was no significant difference between the total rates. This resulted in a total of 8 rates being considered for T-test difference of mean analysis, as indicated in black text in Table 124 and Table 125.

TEACHER	**Teacher-centred vs Teacher-led (d.f. = 14)**	**Teacher-centred vs Student-centred (d.f. = 11)**	**Teacher-led vs Student-centred (d.f. = 17)**
Content	-3.0023	2.4343	6.4852
Activity	-1.1326	-2.9900	-2.5496
Technology	2.4876	1.5489	-2.3870
Activity-Content	-0.0742	1.3811	1.3887
Activity-Technology	-0.7338	-1.9908	-2.3218
Activity-Content-Tech.	0.0944	-0.7367	-1.1340
Content-Technology	0.3894	-0.2232	-0.6822
Task sentiments/attitudes	-0.4572	-0.0136	0.6165
Unrelated/Unclassifiable	-1.3124	0.0018	1.7993
Totals	**-3.7786**	**0.9512**	**4.2668**

Table 124 – T-values of tests for difference in teacher textual discourse per minute between activity designs by Subject types

TEACHER	Teacher-centred vs Teacher-led (d.f. = 14)	Teach-centred vs Student-centred (d.f. = 11)	Teacher-led vs Student-centred (d.f. = 17)
Content	0.0095	0.0332	**0.0000**
Activity	0.2764	0.0123	0.0207
Technology	0.0261	0.1497	0.0289
Activity-Content	0.9419	0.1947	0.1828
Activity-Technology	0.4752	0.0719	0.0329
Activity-Content-Tech.	0.9262	0.4767	0.2725
Content-Technology	0.7028	0.8275	0.5043
Task sentiments/attitudes	0.6545	0.9894	0.5457
Unrelated/Unclassifiable	0.2105	0.9986	0.0898
Totals	**0.0020**	**0.3619**	**0.0005**

Table 125 – p-values of tests for difference in teacher textual discourse per minute between activity designs by Subject types

On the basis of 8 statistical tests and an overall significance level of 5% a Bonferroni adjusted significance level of 0.05/8 = 0.00625 or 0.625% has been adopted for individual tests in the tables above. On this basis the above tests provide evidence to reject the hypotheses that any of the per-student textual discourse rates for the different activity designs were the same.

Analysing T-statistics for the 8 tests at the 0.625% significance level led to one significant result; a difference in mean rate of teacher Content textual discourse contribution per minute for the Teacher-led versus the Student-centred activity types (with respective averages of 5.978 and 1.736 sentences per minute).

Statistical Test 24

H_0: There is *no* difference in the rates of per-student textual discourse per minute between the Teacher-centred, Teacher-led and Student-centred activity designs for each of the different Subject types.
H_1: There is a difference in the rates of per-student textual discourse per minute between the Teacher-centred, Teacher-Led and Student-centred activity designs for each of the different Subject types.

The test statistics and corresponding p-values from performing two-tailed Student T-tests for differences in per-student textual discourse contribution rates between activity designs by individual Subject types are represented in the two tables below.

STUDENT	Teacher-centred vs Teacher-led (d.f. = 14)	Teach-centred vs Student-centred (d.f. = 11)	Teacher-led vs Student-centred (d.f. = 17)
Content	-3.2613	-4.8155	-1.8928
Activity	-0.3000	-1.9978	-2.8611
Technology	-0.7758	-1.3347	-0.3027
Activity-Content	-1.3960	-1.2542	-1.6978
Activity-Technology	-0.2441	-1.0755	-0.9196
Activity-Content-Tech.	insuf. data	insuf. Data	insuf. Data
Content-Technology	insuf. data	insuf. Data	insuf. Data
Task sentiments/attitudes	-1.5626	-1.4777	0.0111
Unrelated/Unclassifiable	-0.6342	-1.0507	-1.1509
Total	**-2.7625**	**-3.5649**	**-2.6456**

Table 126 – T-values of tests for difference in per-student textual discourse per minute between activity designs by Subject types

STUDENT	Teacher-centred vs Teacher-led (d.f. = 14)	Teach-centred vs Student-centred (d.f. = 11)	Teacher-led vs Student-centred (d.f. = 17)
Content	*0.0057*	**0.0005**	0.0755
Activity	0.7686	0.0711	0.0108
Technology	0.4507	0.2090	0.7658
Activity-Content	0.1845	0.2358	0.1078
Activity-Technology	0.8107	0.3052	0.3706
Activity-Content-Tech.	insuf. Data	insuf. Data	insuf. Data
Content-Technology	insuf. Data	insuf. Data	insuf. Data
Task sentiments/attitudes	0.1405	0.1675	0.9913
Unrelated/Unclassifiable	0.5362	0.3159	0.2657
Total	**0.0153**	**0.0044**	**0.0170**

Table 127 – p-values of tests for difference in per-student textual discourse per minute between activity designs by Subject types

In order to improve the reliability of the analysis, only Subject types relating to learning with average rates of student textual discourse contribution per episode of 5 or greater (i.e. 120 contributions across the 24 learning episodes) were considered for analysis (that is Content, Activity and Activity-Content, ref. Figure 49). This resulted in a total of 9 rates being considered for T-test difference of mean analysis, as indicated in black text in Table 126 and Table 127.

On the basis of 9 statistical tests and an overall significance level of 5% a Bonferroni adjusted significance level of 0.05/9 = 0.0056 or 0.56% has been adopted for individual tests in the tables above. On this basis the above tests provide evidence to reject the hypotheses that any of the per-student textual discourse rates for the different activity designs were the same.

Analysing T-statistics for the 8 tests at the 0.56% significance level led to one significant result; the difference in mean rate of per-student Content textual discourse contribution for the Teacher-Centred versus Student-centred activity types (with respective averages of 0.090

and 0.648 sentences per minute). As well, it should be noted that the p-value for the test comparing per-student Content textual discourse for the Teacher-Centred versus Teacher-led activity designs was borderline significant (with an error of 0.01%) and for this reason has also been included in discussions. Note that the average per-student contribution rate for the Teacher-led activity design was 0.437 sentences per minute.

Statistical Test 25

H_0: There is *no* difference in the rates of teacher textual discourse per minute between the Teacher-centred, Teacher-led and Student-centred activity designs for each of the different Interaction types.
H_1: There is a difference in the rates of teacher textual discourse per minute between the Teacher-centred, Teacher-Led and Student-centred activity designs for each of the different Interaction types.

The test statistics and corresponding p-values from performing two tailed T-tests for differences in teacher textual discourse contribution rates between activity designs by individual Interaction types are represented in the two tables below.

In order to improve the reliability of the analysis, only Interaction types with average rates of teacher textual discourse contribution per episode of 5 or greater (i.e. 120 contributions across the 24 learning episodes) were considered for analysis (that is Independent Question, Independent Statement, Statement Response to Question, and Statement Response to Statement, ref. Table 15). As well, differences between rates for the Teacher-Centred and Student-centred were not considered on the basis that there was no significant difference between the total rates. This resulted in a total of 8 rates being considered for T-test difference of mean analysis, as indicated in black text in Table 128 and Table 129.

TEACHER	**Teacher-centred vs Teacher-led (d.f. = 14)**	**Teacher-centred vs Student-centred (d.f. = 11)**	**Teacher-led vs Student-centred (d.f. = 17)**
Independent Question	-2.9243	-0.1647	3.2781
Independent Statement	0.1025	2.5791	3.3156
Question Response to Question	-0.3084	0.6184	1.0573
Question Response to Statement	-0.6289	0.4428	1.5777
Statement Response to Question	-1.0490	-0.2033	0.7824
Statement Response to Statement	-2.3083	-0.6964	2.2188
Question Response to Action	insuf. Data	insuf. data	insuf. Data
Statement Response to Action	-2.3471	-1.8932	-0.0545
Totals	**-3.7786**	**0.9512**	**4.2668**

Table 128 – T-values of tests for difference in teacher textual discourse per minute between activity designs by Interaction types

TEACHER	Teacher-centred vs Teacher-led (d.f. = 14)	Teacher-centred vs Student-centred (d.f. = 11)	Teacher-led vs Student-centred (d.f. = 17)
Independent Question	0.0111	0.8722	**0.0044**
Independent Statement	0.9198	0.0256	**0.0041**
Question Response to Question	0.7623	0.5489	0.3052
Question Response to Statement	0.5395	0.6665	0.1331
Statement Response to Question	0.3120	0.8426	0.4447
Statement Response to Statement	0.0368	0.5007	0.0404
Question Response to Action	insuf. data	insuf. data	insuf. Data
Statement Response to Action	0.0341	0.0849	0.9571
Totals	**0.0020**	**0.3619**	**0.0005**

Table 129 – p-values of tests for difference in teacher textual discourse per minute between activity designs by Interaction types

In order to improve the reliability of the analysis, only Interaction types with average rates of teacher textual discourse contribution per episode of 5 or greater (i.e. 120 contributions across the 24 learning episodes) were considered for analysis (that is Independent Question, Independent Statement, Statement Response to Question, and Statement Response to Statement, ref. Table 15). As well, differences between rates for the Teacher-Centred and Student-centred were not considered on the basis that there was no significant difference between the total rates. This resulted in a total of 8 rates being considered for T-test difference of mean analysis, as indicated in black text in Table 128 and Table 129.

On the basis of 8 statistical tests and an overall significance level of 5% a Bonferroni adjusted significance level of 0.05/8 = 0.00625 or 0.625% has been adopted for individual tests in the tables above. On this basis the above tests provide evidence to reject the hypotheses that any of the per-student textual discourse rates for the different activity designs were the same.

Analysing T-statistics for the 8 tests at the 0.625% significance level led to two significant results:

- a significant difference between the mean rate of teacher Independent Questions for the Teacher-led versus Student-centred activity types (with respective averages of 1.347 and 0.647 sentences per minute).
- a significant difference between the mean rate of teacher Independent Statements for the Teacher-led versus Student-centred activity types (with respective averages of 4.360 and 2.726 sentences per minute).

Statistical Test 26

H_0: There is *no* difference in the per-student of teacher textual discourse per minute between the Teacher-centred, Teacher-led and Student-centred activity designs for each of the different Interaction types.
H_1: There is a difference in the rates of per-student textual discourse per minute between the Teacher-centred, Teacher-Led and Student-centred activity designs for each of the different Interaction types.

The test statistics and corresponding p-values from performing two-tailed Student T-tests for differences in per-student textual discourse contribution rates between activity designs by individual Interaction types are represented in the two tables below.

STUDENT	Teacher-centred vs Teacher-led (d.f. = 14)	Teacher-centred vs Student-centred (d.f. = 11)	Teacher-led vs Student-centred (d.f. = 17)
Independent Question	-1.3744	-2.2689	-2.8510
Independent Statement	-1.3777	-2.2741	-2.6939
Question Response to Question	-0.9481	-0.8563	0.6149
Question Response to Statement	-1.0726	-1.7373	-1.7229
Statement Response to Question	-3.2157	-3.8157	-0.0315
Statement Response to Statement	-1.3636	-2.2929	-2.4696
Question Response to Action	-0.6614	-1.5435	-0.0064
Statement Response to Action	-0.3426	-1.2744	-1.6957
Totals	**-2.7625**	**-3.5649**	**-2.6456**

Table 130 – T-values of tests for difference in per-student textual discourse per minute between activity designs by Interaction types

STUDENT	Teacher-centred vs Teacher-led (d.f. = 14)	Teacher-centred vs Student-centred (d.f. = 11)	Teacher-led vs Student-centred (d.f. = 17)
Independent Question	0.1909	0.0444	0.0111
Independent Statement	0.1899	0.0440	0.0154
Question Response to Question	0.3592	0.4101	0.5468
Question Response to Statement	0.3016	0.1102	0.1030
Statement Response to Question	0.0062	**0.0029**	0.9752
Statement Response to Statement	0.1942	0.0426	0.0244
Question Response to Action	0.5191	0.1510	0.9949
Statement Response to Action	0.7370	0.2288	0.1082
Totals	**0.0153**	**0.0044**	**0.0170**

Table 131 – p-values of tests for difference in per-Student textual discourse per minute between activity designs by Interaction types

In order to improve the reliability of the analysis, only Interaction types with average rates of teacher textual discourse contribution per episode of 5 or greater (i.e. 120 contributions across the 24 learning episodes) were considered for analysis (that is Independent Question, Independent Statement, Statement Response to Question, and Statement Response to Statement, ref. Table 15). As well, differences between rates for the Teacher-Centred and Student-centred were not considered on the basis that there was no significant difference between the total rates. This resulted in a total of 12 rates being considered for T-test difference of mean analysis, as indicated in black text in Table 130 and Table 131.

On the basis of 12 statistical tests and an overall significance level of 5% a Bonferroni adjusted significance level of 0.05/12 = 0.00416 or 0.416% has been adopted for individual tests in the tables above. On this basis the above tests provide evidence to reject the hypotheses that any of the per-student textual discourse rates for the different activity designs were the same. Analysing T-statistics for the 12 tests at the 0.416% significance level led to one significant result; a difference in mean rate of per-student Statement Response to Questions for the Teacher-Centred versus Student-centred activity types (with respective averages of 0.090 and 0.346 sentences per minute).

Appendix B Part D – Example Transcript: Topic 1 Iteration 1

Explanatory notes for this transcript

This transcript of Topic 1 Iteration 1 has been provided in order to illustrate the transcription process underpinning the multimodal discourse analysis as well as to provide an example of teaching and learning in the web-conferencing environment. The following points should be noted in order to effectively interpret this transcript:

- All identities have been represented by two letter abbreviations to preserve anonymity of students.
- Audio comments are signified using a '#' symbol.
- Actions are signified using a '~' symbol.
- All other discourse (not signified using '#' or '~') is text-chat.
- Timestamps have been placed within square brackets throughout the transcript at the beginning of each new minute of the lesson recording and at the beginning and end of the learning episode.

Note that throughout the transcripts a reference to 'MB' is a reference to the teacher.

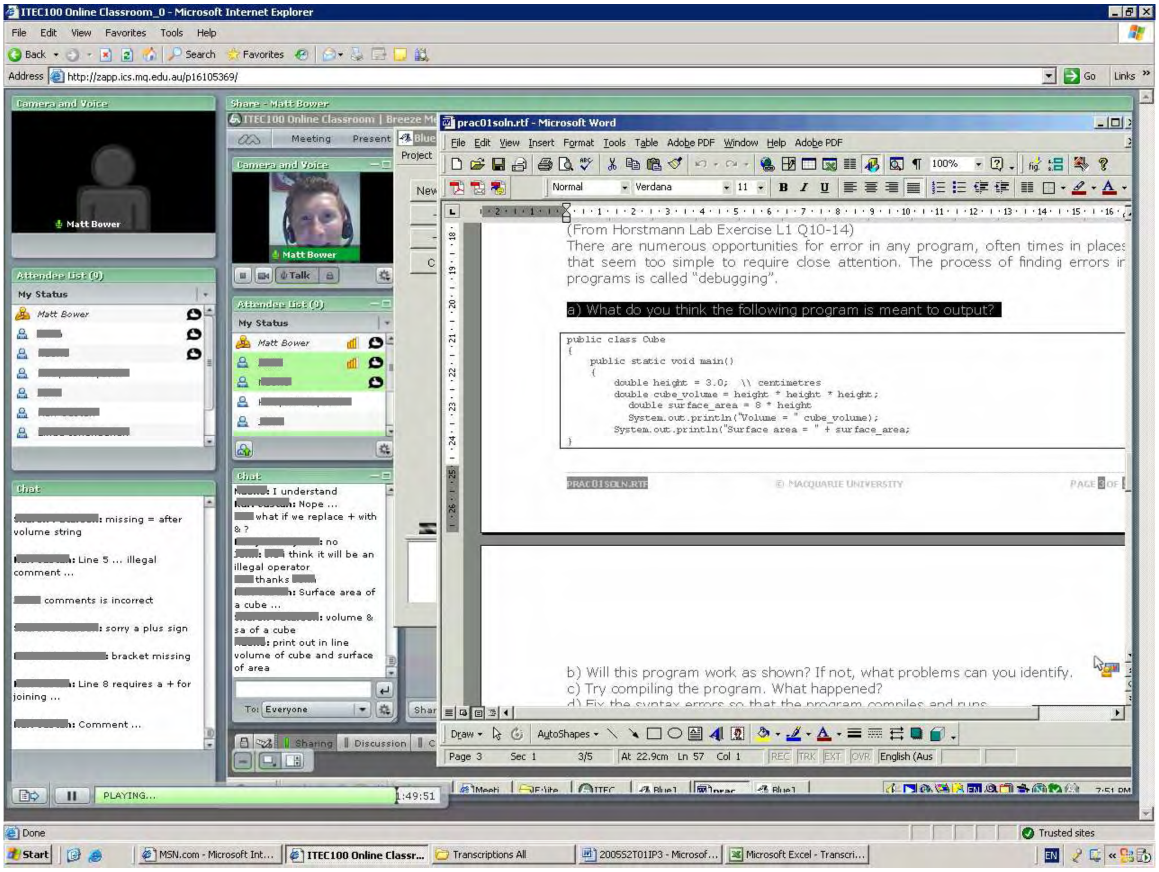
Transcript Topic 1 Iteration 1

//--------------------------------BEGIN TRANSCRIPT---//

[1:45:15]

MB:

The last group activity we might do tonight is this debugging question. What do you think the following program is meant to output? What is it meant to output do you think everyone? Activity 3.



MB:

~ Presents the task via screen-share of conceptual questions document.
~ Selects code in Word document using cursor
~ Presses ctrl-C.

Pedagogical metafunction: Shows how code for this program can be copied from this Word document. Shows how code can be copied and pasted from Word documents.

KC:

Surface area of a cube ...

SP:

volume & sa of a cube

NK:

print out in line volume of cube and surface of area

MB:

Sorry about this everyone. Yeah so basically the program is meant to print out the volume and surface area of the cube.

[1:46:00]

MB:
Unfortunately whoever wrote this program has some errors to find. They need to debug the program we say. So the next question is, will this program work as shown? If not what problems can you identify? So let me know what are some of the problems with this program?

NK:
Too difficult for me

MB:
Well NK says "too difficult". But there are some very simply problems here, syntax problems.

LI:
missing semi colons

MB:
Yeah it's missing a semi colon.

NK:
Ok

SP:
missing = after volume string

MB:
Missing equal after the volume string. The volume string? Not sure about that one SP.

[1:47:00]

KC:
Line 5 … illegal comment …

JR:
comments is incorrect

SP:
sorry a plus sign

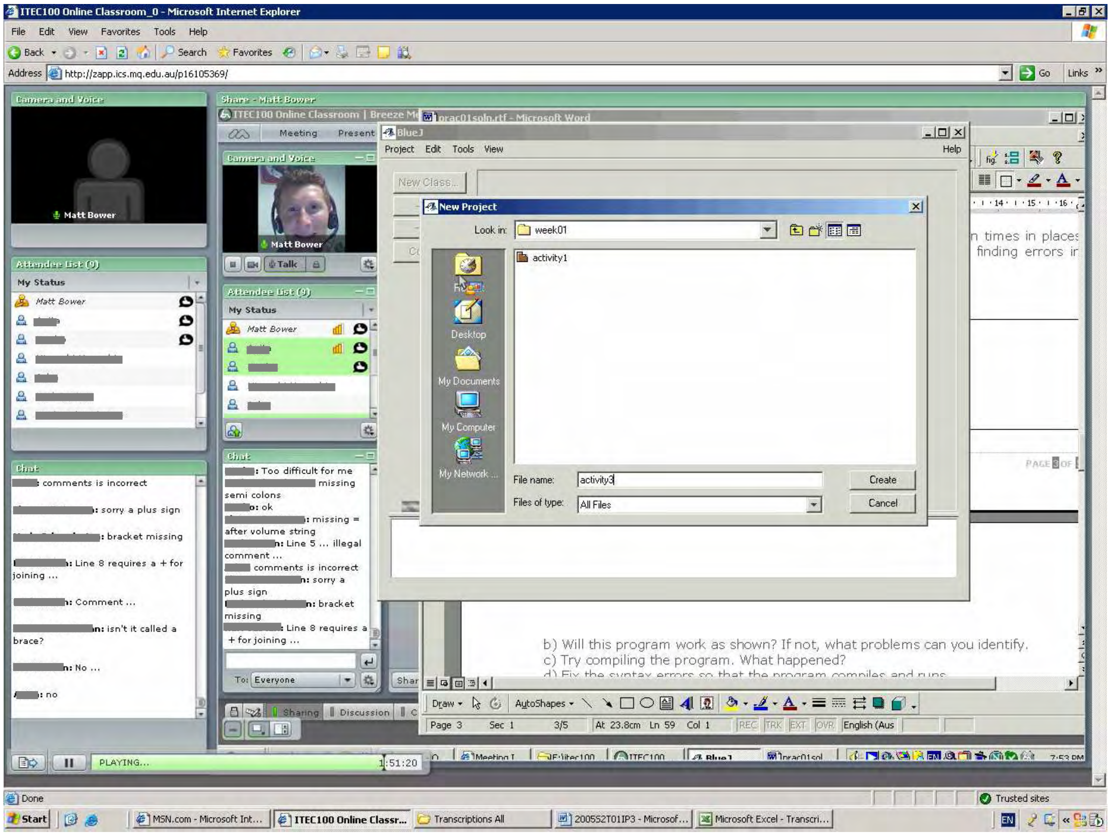
MB:
A plus sign. That's right yes.

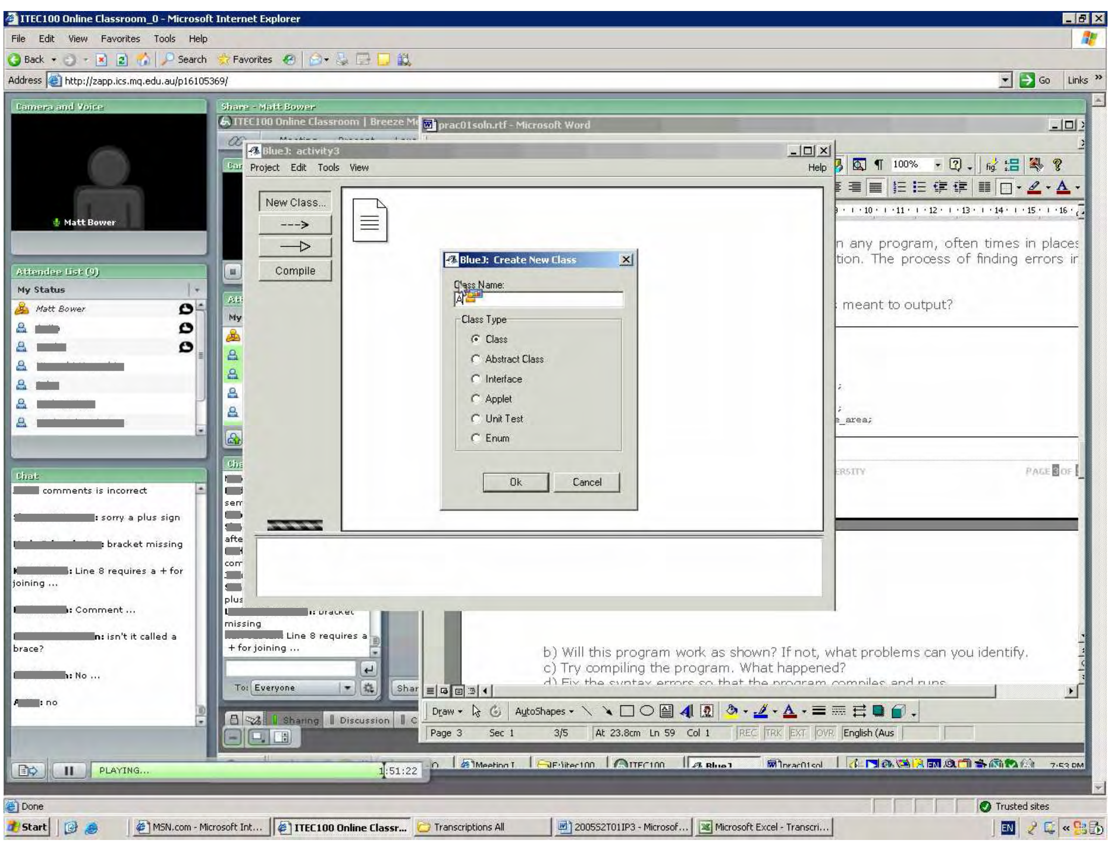
LI:
bracket missing

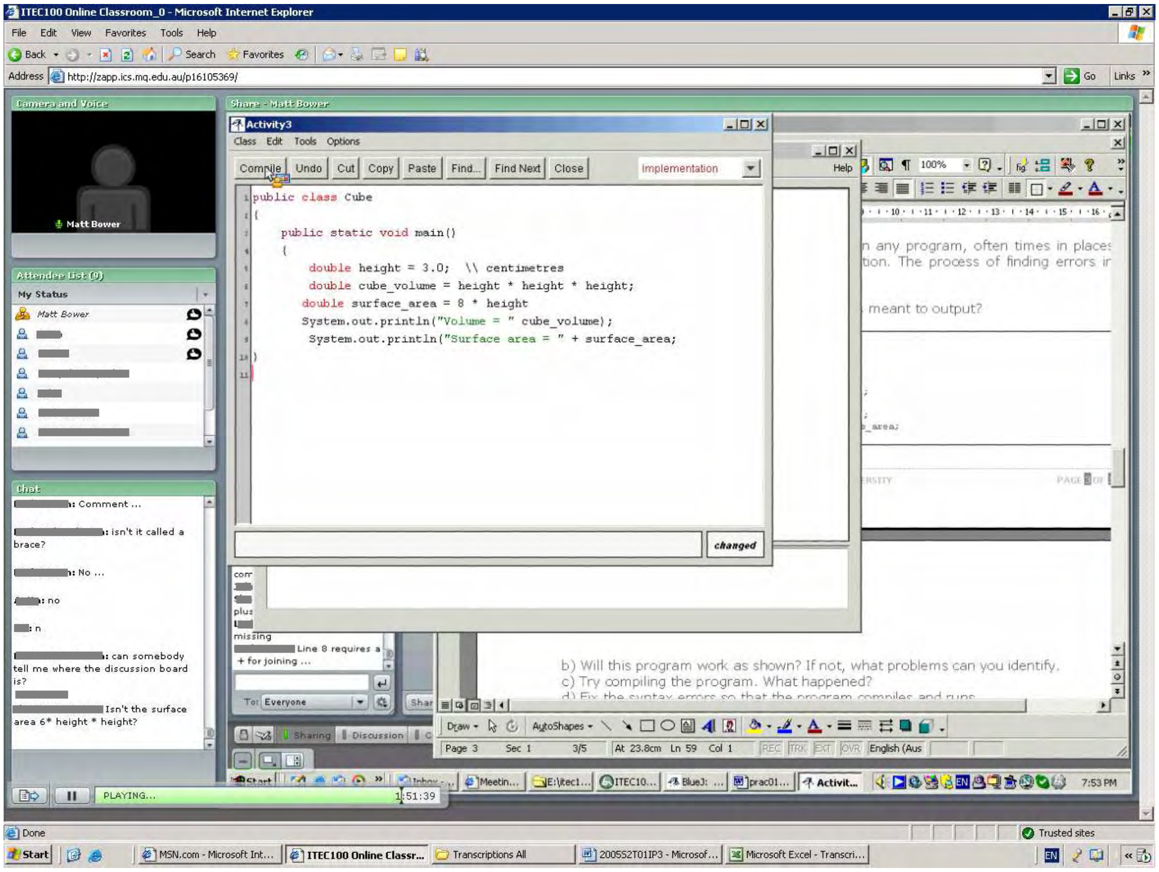
MB:
LI bracket is missing yeah at the end of the final line. So a whole lot of problems.

KC:
Line 8 requires a + for joining ...

MB:
~ Clicks on BlueJ 'file' menu and selects 'open'.
~ Types Activity3 in file save dialogue box.
~ Clicks on 'new class' button and types Activity3 in the class name dialogue box.
~ Double clicks on the Activity3 file icon in BlueJ.
~ Clicks ctrl-V to paste the copied source code over the template source code.
~ Clicks on the compile button.
Pedagogical metafunction: Shows how to open new BlueJ project from file menu and name and save using file system save dialogue. Shows how to create a new class by clicking on New Class button and naming it. Shows how to open the source code file by double clicking. Shows how to copy from Word document and paste into BlueJ source code file, replacing existing code. Shows how to edit source code and compile by clicking on the compile button.


ITEC100 Online Classroom_0 - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address http://zapp.ics.mq.edu.au/p16105369/
Camera and Voice
Matt Bower
Share - Matt Bower
pracO1soln.rtf - Microsoft Word
BlueJ
Project Edit Tools View Help
New Project
Look in: week01
activity1
Desktop
My Documents
My Computer
File name: activity3
Files of type: All Files
Create
Cancel
Attendee List (8)
My Status
Matt Bower
Chat
[redacted]: comments is incorrect
[redacted]: sorry a plus sign
[redacted]: bracket missing
[redacted]: Line 8 requires a + for joining ...
[redacted]: Comment ...
[redacted]: isn't it called a brace?
[redacted]: No ...
[redacted]: no
[redacted]: Too difficult for me
b) Will this program work as shown? If not, what problems can you identify.
c) Try compiling the program. What happened?
PLAYING...
51:20
Done
Trusted sites
Start
MSN.com - Microsoft Int...
ITEC100 Online Classr...
Transcriptions All
200552T01IP3 - Microsof...
Microsoft Excel - Transcri...


ITEC100 Online Classroom_0 - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address http://zapp.ics.mq.edu.au/p16105369/
Camera and Voice
Matt Bower
Share - Matt Bower
pracO1soln.rtf - Microsoft Word
BlueJ: activity3
Project Edit Tools View Help
New Class...
Compile
BlueJ: Create New Class
Class Name:
Class Type
Class
Abstract Class
Interface
Applet
Unit Test
Enum
Ok
Cancel
Attendee List (8)
My Status
Matt Bower
Chat
[redacted]: comments is incorrect
[redacted]: sorry a plus sign
[redacted]: bracket missing
[redacted]: Line 8 requires a + for joining ...
[redacted]: Comment ...
[redacted]: isn't it called a brace?
[redacted]: No ...
[redacted]: no
b) Will this program work as shown? If not, what problems can you identify.
c) Try compiling the program. What happened?
PLAYING...
51:22
Done
Trusted sites
Start
MSN.com - Microsoft Int...
ITEC100 Online Classr...
Transcriptions All
200552T01IP3 - Microsof...
Microsoft Excel - Transcri...



MB:

Lets try compiling the program and see what happens. So what we might do now is project, close this one, create a new project called Activity 3. And there's the program. Let's see what happens now if we try and compile it.

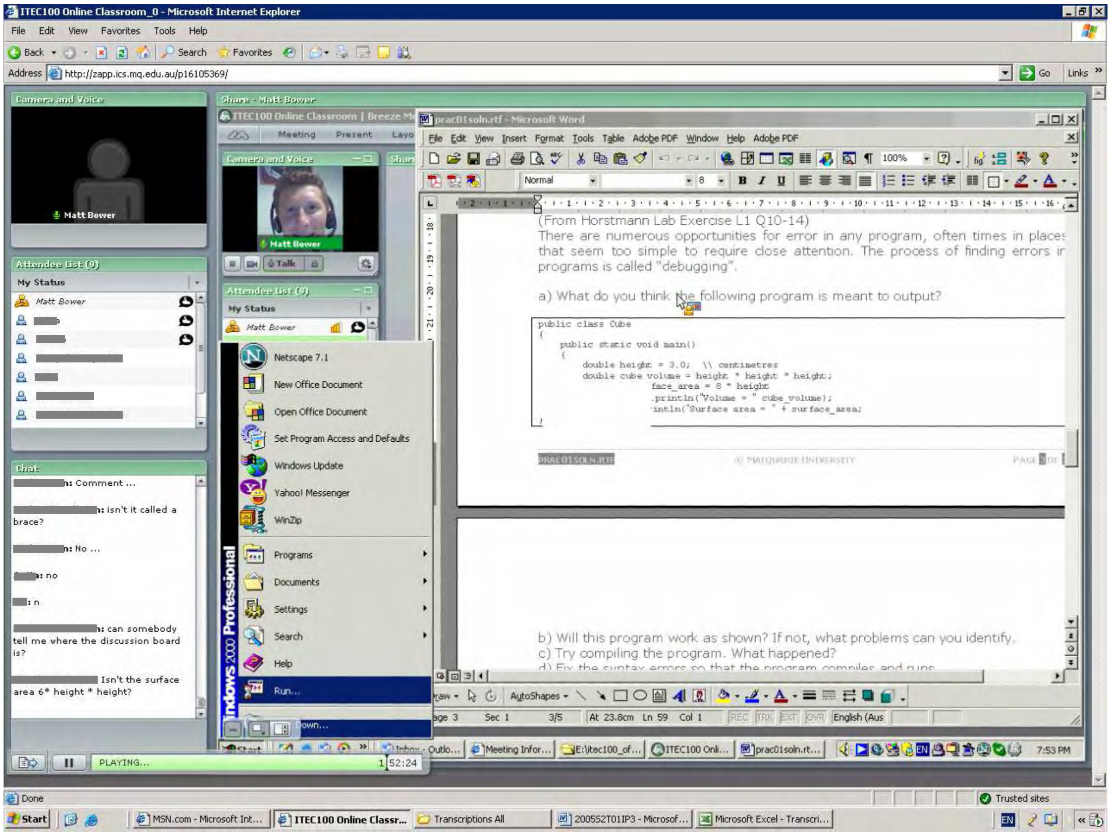
[1:48:00]

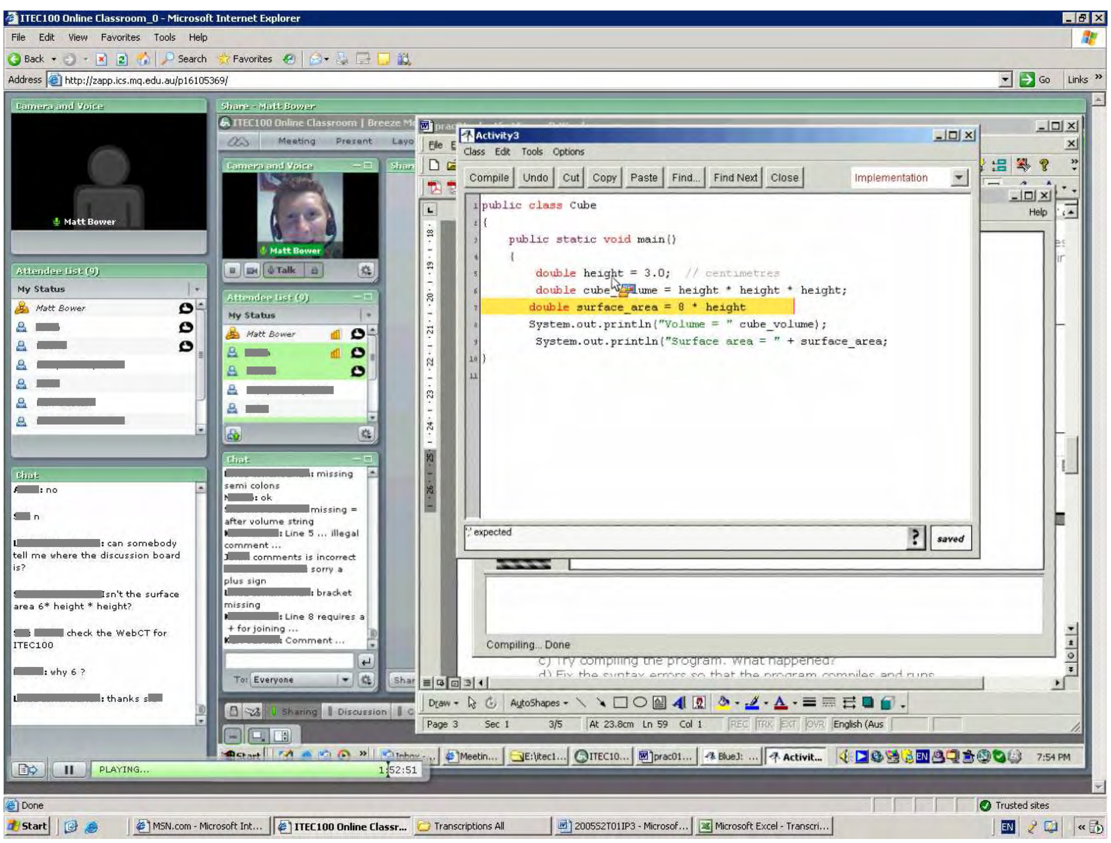
MB:

And I just stuffed up majorly! I just shut down the whole program. Hopefully yep here we go let's compile. Illegal character 92. Now this may be a word copy paste issue. I hope not.

MB:

~ Selects BlueJ from the 'programs' 'file' menu.
~ Double clicks on the Activity 3 class icon.
~ Clicks on compile. IDE returns Illegal character 92 message.
Pedagogical metafunction: Shows how to reopen the BlueJ application using the Program Menu in this instance. Shows how to reopen the BlueJ using the Program Menu generally. Shows how to open the Activity 3 source code file. Shows how to open source code files generally. Shows how to compile this file. Shows how to compile generally.


ITEC100 Online Classroom_0 - Microsoft Internet Explorer
prac01soln.rtf - Microsoft Word
(From Horstmann Lab Exercise L1 Q10-14)
There are numerous opportunities for error in any program, often times in places that seem too simple to require close attention. The process of finding errors in programs is called "debugging".
a) What do you think the following program is meant to output?
b) Will this program work as shown? If not, what problems can you identify.
c) Try compiling the program. What happened?
[redacted]: Comment ...
[redacted]: isn't it called a brace?
[redacted]: No ...
[redacted]: no
[redacted]: n
[redacted]: can somebody tell me where the discussion board is?
[redacted] Isn't the surface area 6* height * height?


ITEC100 Online Classroom_0 - Microsoft Internet Explorer
Activity3
public class Cube
public static void main()
double height = 3.0; // centimetres
double surface_area = 8 * height
System.out.println("Volume = " cube_volume);
System.out.println("Surface area = " + surface_area;
Compiling... Done
[redacted]: missing semi colons
[redacted]: ok
[redacted]: Line 5 ... illegal comment ...
[redacted]: bracket missing
[redacted]: Line 8 requires a + for joining ...
[redacted] check the WebCT for ITEC100
[redacted]: why 6 ?
[redacted]: thanks

KC:
Comment…

MB:
Ok the comments around the wrong way. Let's hope that's what it's complaining about. Yes thank you KC. The backslashes should have been forward slashes for a comment. The next compile error was it says a semi colon was expected.

MB:
~ Highlights the two backslashes and types two forward slashes.
~ Clicks on the compile button. IDE shows semi-colon expected error and highlights line. ~ Places cursor at end of line and types semi-colon character.
~ Clicks on the compile button again. IDE returns "} expected" statement.
Pedagogical metafunction: Shows how to change the comments to the right way around. Shows that line comments need to be forward slashes. Shows how to compile again after debugging code. Shows the iterative process of debugging. Shows how to place semi colon. Shows how to interpret the compiler error "Semi-colon expected".

[1:49:00]

MB:
Ok lets try again. Oh another error. It says that a bracket was expected. But we've already had SP say "hey you need a plus symbol between this string". And what will happen when we put plus cube volume? Well cube volume gets calculated as height times height times height. Cube volume is a number. Don't worry too much at this stage. Double just means decimal at this stage. And since we made height equal 3, this will print out volume equals and turn cube volume which is 3 times 3 times 3, or 27. It will turn that into a number.

MB:
~ Puts plus into System.out.println to concatenate.
~ Selects the three different heights with the cursor.
Pedagogical metafunction: shows how the String requires a plus symbol to concatenate. Shows how Strings require '+' symbol to concatenate. Highlights each instance of the "height" variable to emphasize how multiplication occurs. Demonstrates use of the highlighting principle.

[1:50:00]

MB:
It accepted that now but finally we need to close off this bracket. Let's try now.

MB:

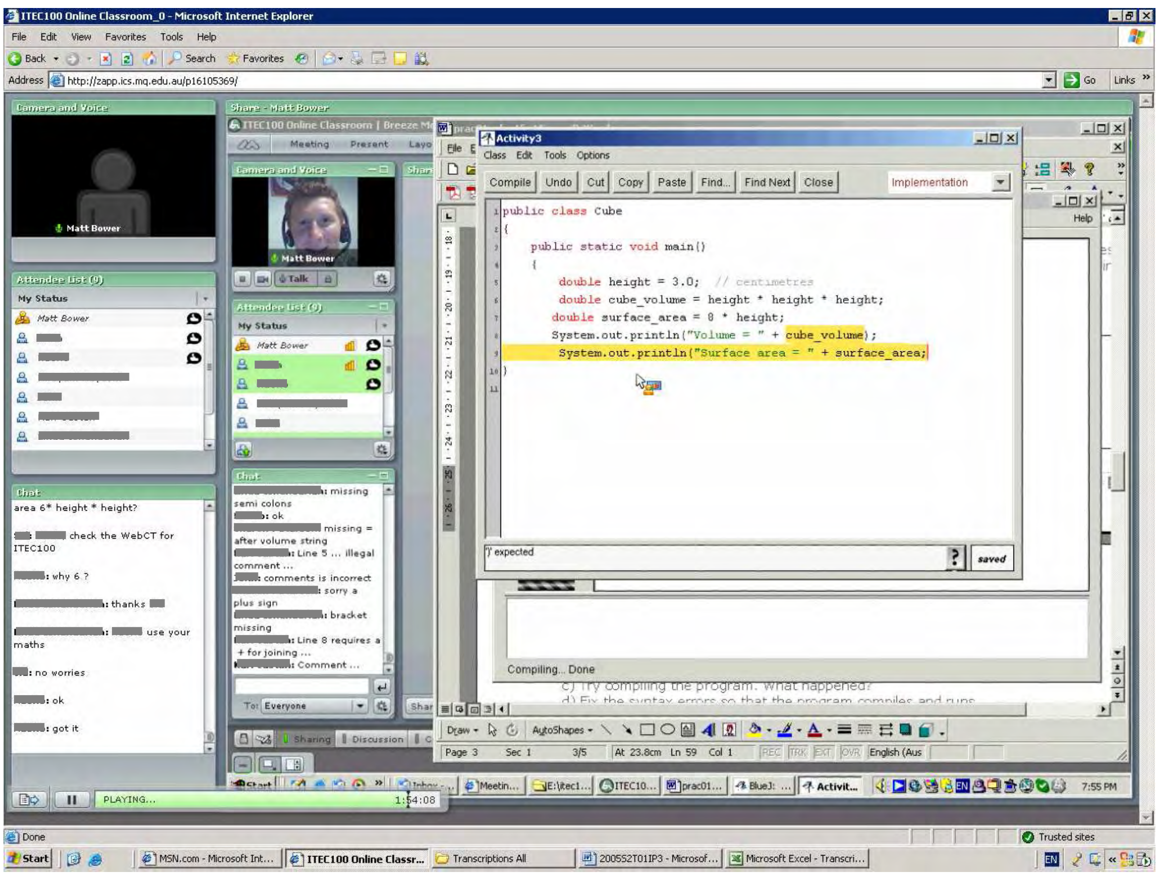
~ Types closing bracket on System.out.println.
~ Clicks compile. IDE shows '}' expected error message and text highlighted.
Pedagogical metafunction: Shows how brackets required at the end of the println statement. Shows how println statements require closing brackets. Shows how to compile this program. Shows how to compile programs generally.

MB:

There's another bracket missing down here to close off this bracket.

MB:

~ Types closing brace at end of main method.
~ Clicks compile. IDE shows 'class compiled - no errors' message.
Pedagogical metafunction: Shows how brace required at the end of the main method. Shows how methods require closing braces. Shows how to compile the program. Shows how to compile programs generally.



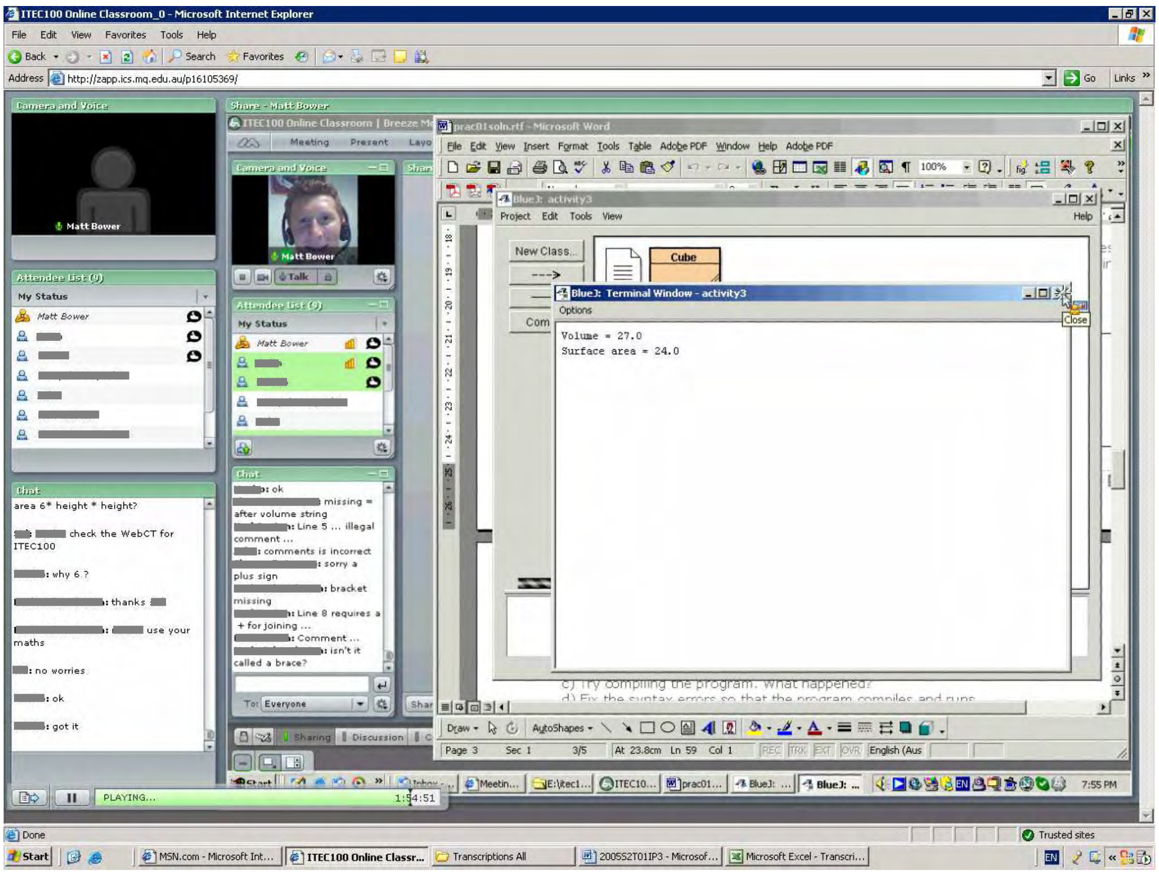
MB:

No errors! Wow. Let's run it.

MB:

~ Clicks on top right corner of source code window.
~ Right clicks on source code file icon.
~ Chooses 'void main(String[] args)' from the popup menu and clicks OK on the popup dialogue box to indicate no method parameters required. IDE runs program and pops up terminal window with output.

Pedagogical metafunction: Shows how to close the code window. Shows how to close windows generally. Shows how to run this program. Shows how to run programs generally.

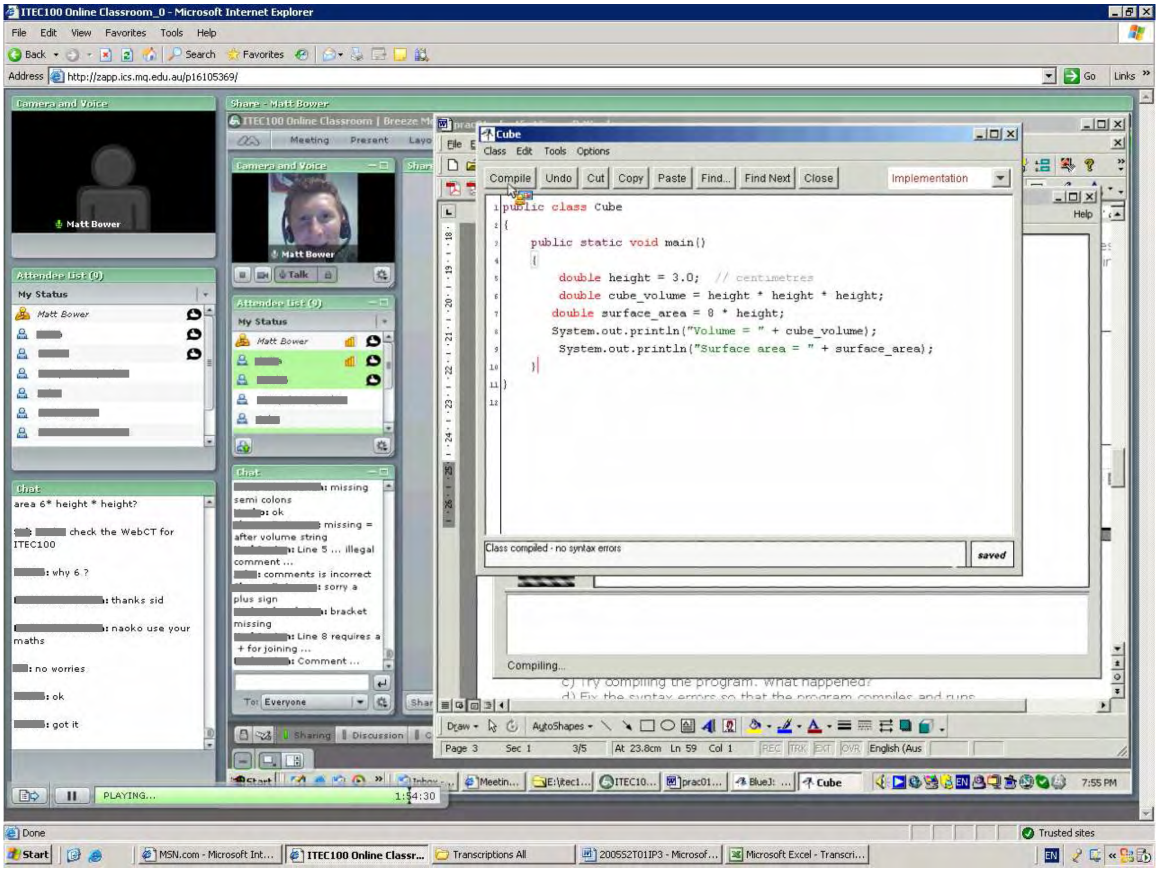


LI:

isn't it called a brace

MB:

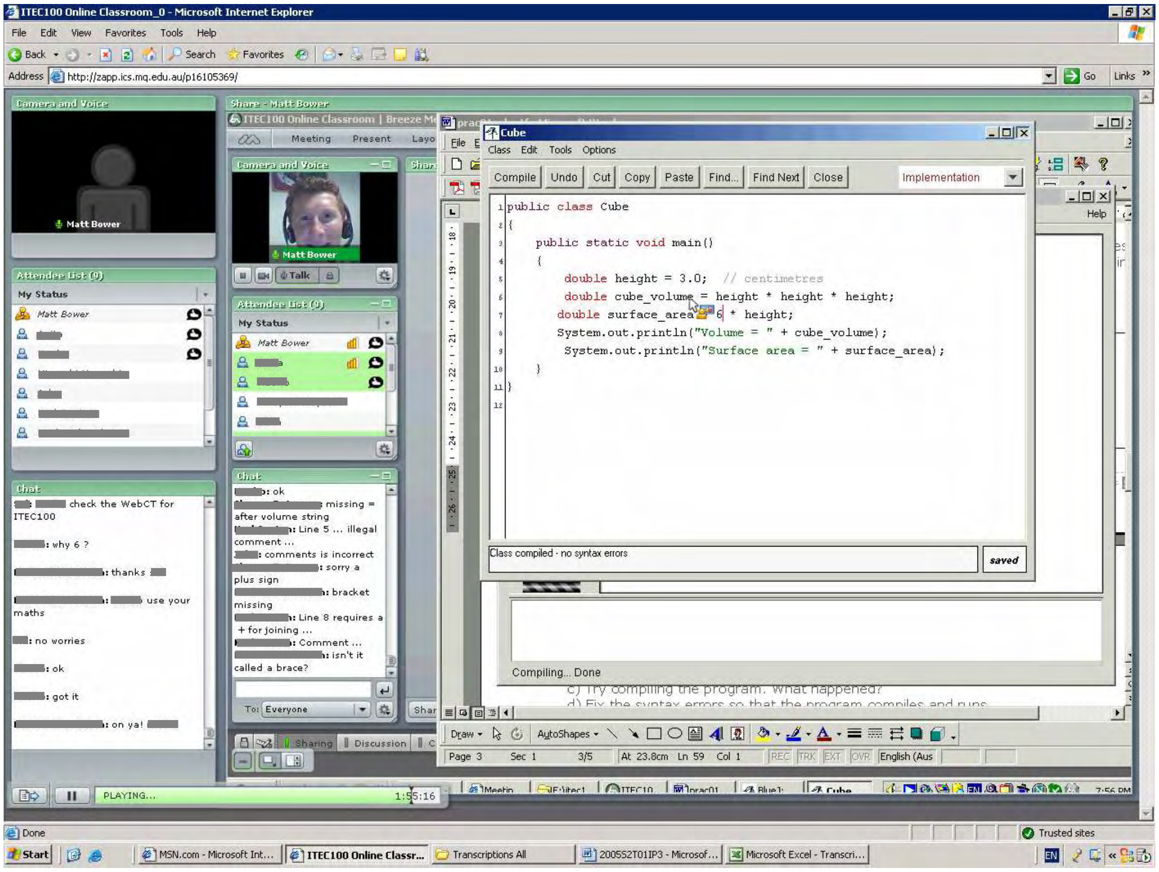
And it does it. Bracket brace, yeah brace is a probably better thanks LI. But there's still one problem, a logical error that the surface area should be 6 times the height, not 8. The compiler won't pick that up but your testing should.



MB:

~ Clicks on top right corner of the terminal window.
~ Double clicks on the source code icon.
~ Deletes the ‘6’ and types ‘8’.
~ Clicks on the ‘compile’ button. IDE shows no errors message.
~ Clicks on top right corner of source code window.
~ Right clicks on source code file icon and chooses ‘void main(String[] args)’ from the menu and clicks OK on the popup dialogue box to indicate no method parameters required. Program runs and IDE pops up terminal window with output.

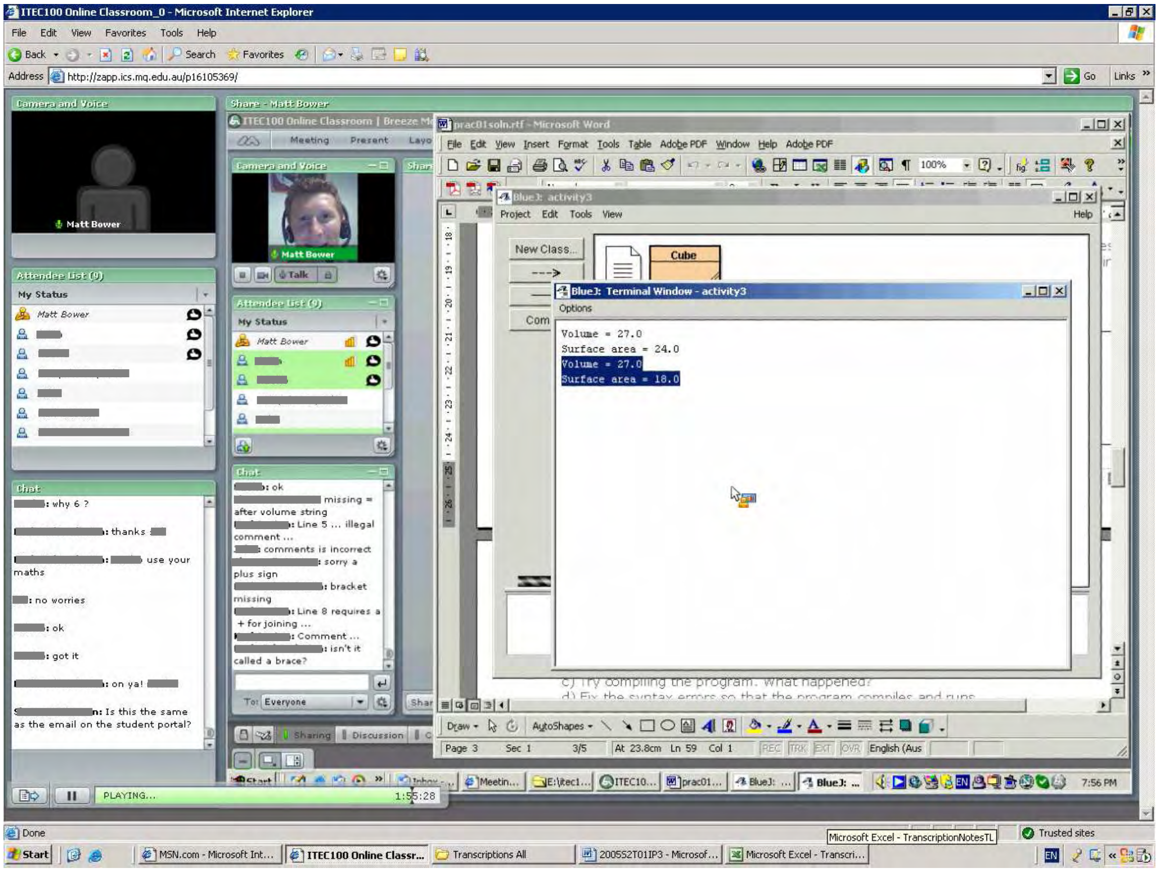
Pedagogical metafunction: Shows how to close the terminal window in this case. Shows how to return to code. Shows how to select the source code file Activity3. Shows how to select a source code file. Changes the numeric constant from ‘6’ to ‘8’to rectify the logical error. Shows how to debug logical errors in the source code. Shows how to compile and run the Activity6 program. Shows how to compile and run programs.



MB:

Now when we run it, it gives the correct surface area.

[1:51:00]



MB:

~ Clicks and drags mouse over the output.

Pedagogical metafunction: Highlights the new output that has been displayed on the terminal window to distinguish it from the old output. Demonstrates how to highlight.

LI:

can somebody tell me where the discussion board is?

MB:

That was very quick because there's a last one couple of things I want to show you. Are there any questions about that? I'll give you these things to upload, ah to download. If there are no questions there's just a couple of things I want to show you about the division of ICS system. Alright so I'll give you the solution for the other activities. What we'll do now…

KC:

No ...

AR:
no

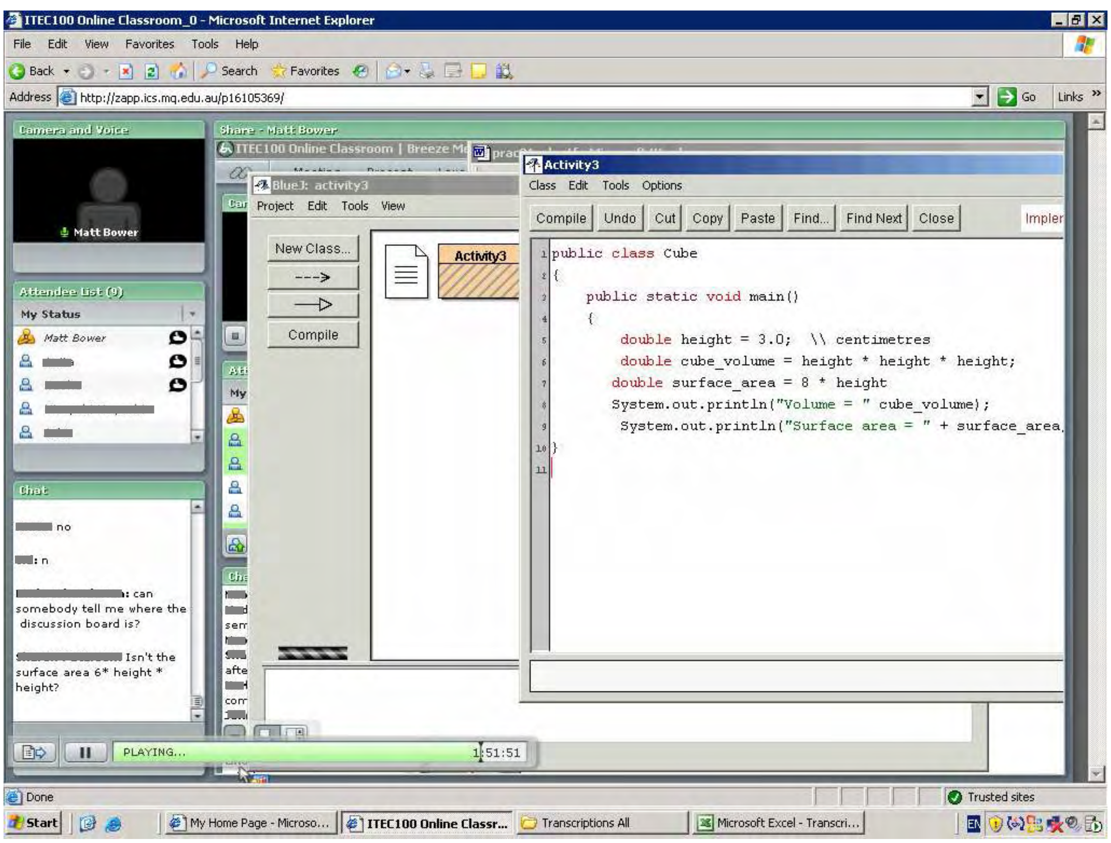
SA:
n

SP:
Isn't the surface area 6* height * height?

MB:
Oh it should be 6 x height x height. Isn’t that what was there?

SA:
LI, check the WebCT for ITEC100

MB:
Maybe I needed, I did need to add another times height thank you SP.



[1:52:00]

NK:
why 6 ?

LI:
thanks SA

LI:
NK use your maths

SA:
no worries

NK:
ok

NK:
got it

LI:
on ya! NK

[1:52:15]

//--------------------------------END TRANSCRIPT---//

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