Narrative Evolution: Learning from Students' Talk about Species Variation.

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Abstract

Learners do not always enjoy productive interactions with Multimedia Interactive Learning Environments. Their attention can be distracted away from the educational focus intended by designers and teachers through poor design and operational inadequacy. In this paper we describe a study of groups of learners using a multimedia CD-ROM research tool called *Galapagos*. This tool was developed to enable us to observe groups of learners interacting with different versions of the same multimedia content. These different versions implemented different forms of guidance for learners both within the presented narrative structure of the material and in the tools offered to learners to help them build the individual content elements into a coherent whole. Our empirical work was conducted with groups of learners within their educational establishment using the *Galapagos* CD-ROM as part of their studies for national examinations in Biology. Their sessions with *Galapagos* were recorded using video and audio and our analysis of their dialogue has enabled us to gain a greater understanding of the factors that contribute to productive, educationally focused learning interactions. Through the construction of different representations we have been able to co-ordinate information about interactivity between learners and system *at* the interface with interactivity between individual learners within the group *around* the system interface. Varying the quantity and quality of guidance impacts upon the trajectory learners construct through multimedia content; it also influences the manner in which they use the

facilities provided by system designers to assist them in their construction of task answers.

Introduction and Theoretical Background

This paper explores the collaborative use of Multimedia Interactive Learning Environments (MILEs) in the form of educational CD-ROMs. We discuss the role of learner dialogue and reflection in clarifying our understanding of what learners do when they use multimedia and how system design can impact upon their experience. The work reported here takes the form of three detailed case studies of groups of users interacting with a CD-ROM research tool we developed specifically to allow us to investigate users reactions to changes in the structure of the material they were being invited to interact with. Our data sources include video and audio recordings and a qualitative approach is taken to the analysis of this material. This approach has allowed us to start unpacking the complexities within the interactions between users and the CD-ROM and between individual users in a group.

The research we describe is theoretically grounded in our investigations of the role of narrative in the design and comprehension of multimedia educational software. Narrative is not simply aesthetic, it is fundamentally linked to cognition and understanding. Narrative provides a macro-structure which creates global coherence, contributes to local coherence and aids recall through its network of causal links and signposting. The structure provides a linear dynamic which can accommodate diversions and tangents and allows learners to maintain their plans and goals.

The search for a satisfactory definition which might constrain what we mean by narrative in this context has proved somewhat elusive. However, the working definition for narrative in interactive educational media that we adopted for the purpose of this study is that narrative is: *a process of both discerning and imposing structured meanings which can be shared and articulated.* This definition is still somewhat broad and we hoped to clarify it further through our empirical studies. It does however reflect the idea that there is a ‘designed-in’ narrative and a narrative as perceived by learners and that these two views may not coincide.

Why Narrative and Multimedia?

Multimedia offers the potential for learners to have access to, and control of, their interactions with a variety of different media: video, audio, text etc. In theory then learners could benefit from a rich and varied learning experience which they can tailor to their individual needs. However, the benefits of multimedia are also its potential pitfalls, in terms of providing coherence throughout both individual units or micro-narratives and the overall structure or macro-narrative. **[add reference to Kintsch and Lydia’s reaction to the comments from reviewer 1.]** There are precedents for suggesting that books, films, drama and other narrative media can inform the design and usability of multimedia (Clanton, Iannella & Young 1992; Laurel, 1993; McKendree & Mateer 1991). Here we focus on how the form and function of narrative facilitates or impedes learning. The introduction of hypertexts has seen a resurgence of interest in the form and function of narrative (Bolter, 1991 Landow, 1992; Murray, 1997; O’Donnell, 1998) there has, however, been less interest in the role of narrative in non-literary texts and, particularly, in educational media.

An effective Multimedia Interactive Learning Environment (MILE) should provide global coherence within the macro-narrative, local coherence within the micro-narrative and a network of potential links between the two which enable learners to focus on content, maintain a clear goal and construct a personally meaningful understanding of the underlying concepts (Plowman, Luckin, Laurillard, Stratfold, & Taylor, 1999). In order to inform the designers of such MILEs we needed to know the nature of the interactions learners were experiencing with the type of CD-ROMs typically used within schools. We therefore conducted a series of pilot studies during 1996 and 1997. These early studies were of groups of learners, ranging from 12 - 15 years of age, using commercially produced CD-ROM's relevant to their studies at that time. It was, and still is, common educational practice to allow learners to use CD-ROMs in small groups. Indeed, there is evidence to suggest that computers can play an important role in engendering peer collaboration and fostering learning (e.g. Crook, 1994; Scardamalia and Bereiter, 1996; Guzdial, Kolodner, Hmelo, Narayanan, Carlson, Rappin, Hubscher, Turns, & Newstetter 1996; Dillenbourg, Baker, Blaye, & O'Malley 1995; Roschelle, 1992). These observations of group multimedia use also allowed us to study the conversations between learners as they used the CD-ROM. The following dialogue extract is taken from an interaction between a group of students who have been asked to find information about the effects of nuclear bombing during World War 2 in order to complete a worksheet provided by their teacher. They are using a commercially produced History CD-ROM and this conversation occurs approximately 12 minutes into the session:

Speaker	Comment
1	There is no film there, is there
1& 2	No
2	That one has no film there, either
3	Its the last one
2	Is there any text to go with it? *(Reading from text entitled "cities in Hiroshima")*
2	One more.
1	It is Yorkshire television, made it. Err. What do they do, they do? They make Emmerdale, and CD's?
3	I think they have got one on the first world war now, as well
1 & 2	Have they?
2	Hitler? Do you want Hitler?

They find information about Hiroshima which is relevant to their task but pay no attention to it. Nuclear bombing was the teacher's intended educational focus for the session, but this group are failing to interact at this conceptual level and are concentrating instead upon issues to do with the quality of the presentational media. In many of these early observations much of the group discussion was associated with operations and procedures rather than the educational content of the material (Plowman, 1996). On other occasions during this study, learners' interactions with the content were present, but fragmented through the same sort of distraction from system features.

Through the research reported here we have been able to explore this lack of focus and its relationship to the structure of the CD-ROM. In particular, we wished to investigate the relationship between the guidance provided within the structure of the CD-ROM and the nature of the interactions learners experienced. We hoped that in this way we would be able to offer advice about the way CD-ROM material might be better designed to assist learners in their construction of personal meaning. To this end, we developed a research tool called *Galapagos*. In this paper we describe the methodology and analysis of the *Galapagos* study. We discuss our approach to representing and analysing the relationship between system feature use and types of learner talk. Through our studies with *Galapagos* we wanted to build a model of the process which learners pursue when they use MILEs and to identify what leads to engagement with the content rather than the media. The discussion of the results of our analyses in this paper concentrates upon the relationship between learner talk and system feature use. Our purpose is to explain the way in which we have analysed learner talk and its contingency to system feature use in order to elicit information about learners experiences with MILEs.

The *Galapagos* Study

The CD-ROM

We built the *Galapagos* CD-ROM as a research tool. It implements a three-way presentational manipulation of the same content material about Darwin's visit to the Galapagos islands and his resultant theory of evolution. These three versions are called: *Linear*, *Resource Based Leaning* and *Guided Discovery Learning*. In all 3 versions of *Galapagos* learners are set the same task, they are asked to use the resources provided on the CD-ROM to construct an explanation in an on-line notepad of the variations in the wildlife on the islands. In all three versions there are also the same 8 sections of content material, each of which deals with a particular aspect of Darwin's visit. For example, there is a section which describes his arrival and first impressions of the Galapagos islands, and sections about the identity of the different islands and the different varieties of finch which lived in these different locations. The full set of sections is as follows; the section numbers are used to refer to sections throughout this paper, but were not part of the structure presented to our users:

Introduction
Section 1: About Darwin's visit
Section 2: About Islands
Section 3: Island Formation
Section 4: Island Location
Section 5: Trade Winds
Section 6: Currents
Section 7: About the Birds
Section 8: Explore the Islands

Each of these sections of content has its own micro-narrative and its own possibilities for interaction in the form of movies to play or images to click on. In addition, each of these sections has a role within the overall story about Darwin's work on evolution. The micro-narrative within these sections is stronger in some cases than others. The section entitled 'About Darwin's visit' has a strong story about his trip and arrival, whilst the section called 'Explore the Islands' invites the learner to choose an island, after which a list of the species of birds which inhabit it is presented. In addition to these sections of content material all versions of *Galapagos* allow the user access to the following information via a tool bar at the bottom of the screen

A reminder about the task they have been asked to complete at the outset of their interactions with *Galapagos*.
An editable Notepad in which they can take notes and write their answer.
A Model Answer which is a sample of an acceptable answer to the task they have been set and which can only be accessed when they have written 50 words in the notepad.
A script window which contained the transcript for all audio material.

(for more detail about these features see Plowman, Laurillard, Stratfold, & Taylor, 1998):

The tool bar can be seen at the bottom of the screen shot illustrated in Figure 1.

The difference between the versions is in the amount of guidance the system provides to users to help them navigate through the available material:

1. Linear: When the material on this version is first viewed the system moves automatically between the content sections. After this, learners can elect to go back to certain selected points within this presentation and from there, they can move either backwards or forwards between the different sections of content. It provides no full menu or search facility and no overview of the structure of the CD-ROM. This version was designed to present an easily identifiable narrative which would enable us to investigate the extent to which MILEs should emulate more familiar narrative structures such as films.
2. Resource-Based Learning (RBL): Learners have free access to all sections of the CD-ROM through a menu and free text search facility. This version was designed to reflect the encyclopaedic nature of the existing commercially available CD-ROMs we had observed in our pilot studies of classroom use.
3. Guided Discovery Learning (GDL): The menu is expanded into a textual guide which breaks the initial task down into sub-tasks and suggests the relevant sections of the CD-ROM to access for information about these sub-tasks. In addition, as with the RBL version, learners have access to a free text search.
4.

Figure 1 illustrates a screen shot of the Guided Discovery Learning version of Galapagos with a section of content called "Trade Winds" in use.

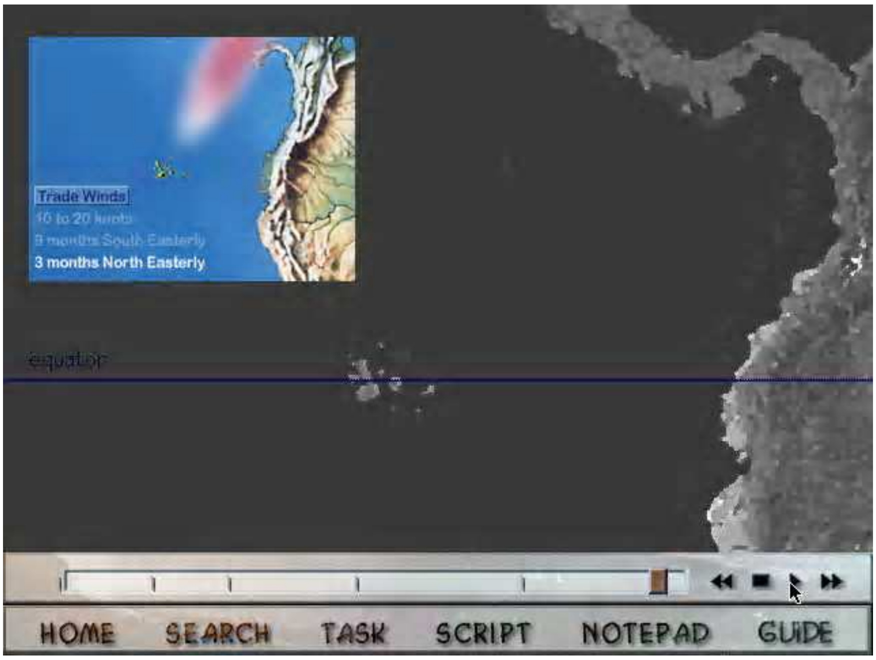

Fig. 1. ***Galapagos*** **Trade Winds**

We hoped that the three different *Galapagos* designs would elicit different kinds of behaviour from learners and allow us to explore the extent to which the presented narrative influenced their style of interaction and how they used the system features provided to make sense of the material. We have already highlighted our desire to explore the relationship between the focus within educational experiences involving MILEs and the design of the MILE being used. The central question we explore here is: “When are learners engaged with educational content as opposed to the medium of communication?”. In particular, we focus in this paper upon two questions where the analysis of dialogue has been of particular benefit:

1. How can manipulation of the presented narrative within a CD-ROM impact upon educational focus? We use presented narrative here to describe the manner in which the material available is structured and the nature and extent of the guidance through this content users of the CD-ROM are given.
2. How are the various system features used by learners? As designers we may, for example, include a model answer because we believe that its presence will motivate learners to construct an answer of their own and offer them guidance about what constitutes an answer in this context. Without exploring the use of such features we cannot however be sure that they are used in the way we intended or believed that they would be.

The discussion of the results of our analyses here concentrates upon the relationship between learner talk and system use. Our purpose is to explain:

- the way in which we have analysed learner talk and its contingency to system use and
- to elicit from this information a clearer picture about the process and focus of interactions learners experience when they use a MILE.

Participants

Four groups of three students, aged between 15 and 21 years, used one of the three versions of *Galapagos*. The 36 students were based in two different situations and all were studying for a national examination in Biology. A session using *Galapagos* and completing the task (to explain the variation in the wildlife on the Galapagos Islands and write the answer in the notepad) to their own satisfaction typically took about 45 minutes.

Figure 2 illustrates the structure of the *Galapagos* study.

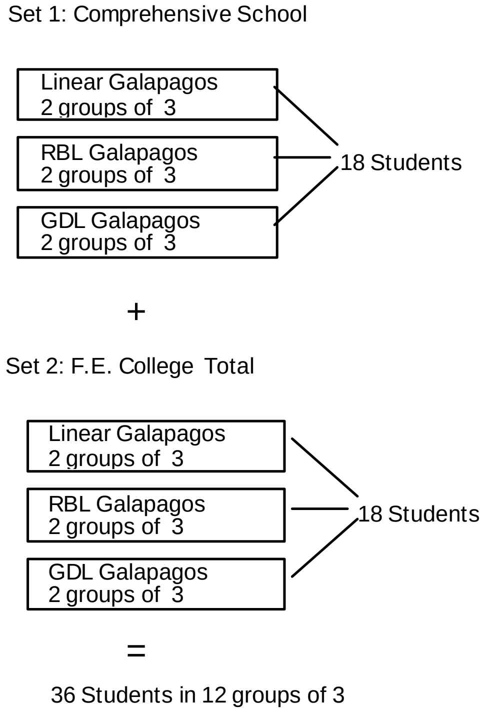

Figure 2 Structure of Evaluation studies

Data Collection

The number of participants was small and it was not our aim to adhere to a rigorous experimental methodology. The interactions around the computer were complex and we wanted to increase our understanding of the process learners go through when they interacted with the CD-ROM: When did they focus upon the content rather than the mechanics of interaction?. It was therefore our goal to study each of our groups in detail; to unpack the interactions between individual group members whilst they used the CD-ROM; to explore the interactions between the group and the CD-ROM and to study its subsequent impact upon the individual learner’s reflections. Each session can be regarded as a case study in its own right. In addition, useful comparisons can be drawn between the use of particular system features across the different groups. These comparisons should provide useful information for the design of future CD-ROMs, both for educational use and further research.

We collected a variety of data which included:
Video recordings Every group session had two video-recorded sources: one recorded the group of learners at the computer to capture talk, movement, gesture and machine interaction; the other was the screen image, taken from the computer via a scan converter. These videotapes enable us to analyse learner talk and behaviour in detail and to trace the emerging notepad answers they construct collaboratively.

Audio Recordings
After each group of learners had used the CD-ROM they were asked to use a simple tape machine to record their individual experiences by focusing upon a series of questions. They were asked to re-tell what they had just done for an absent friend and to answer specific factual questions about Darwin’s visit to the Galapagos islands. These audio transcripts provide evidence about what each individual learner has gained from their collaborations with peers and their interactions with the CD-ROM. They offered the learners a means of expressing their impressions and recollections of what they had achieved in privacy without the need for writing. These records offered us a valuable opportunity to gain insights into the learner's reflective awareness and emerging understanding.

Video and audio data was supplemented by

- A pre-use questionnaire establishing computer experience and confidence,
- A teacher assessment of each student's oral abilities,
- The learners’ entries in the Notepad,
- Observation of the teacher's introductory lesson,
- The teacher’s assessment of the different Notepad responses.

This wide variety of methods for collecting data allowed us to observe responses to different design features and examine the ways in which learners’ knowledge about Darwin’s theory of species variation developed through their interactions with each other and with the CD-ROM.

Analysis

Our approach to dialogue analysis relies upon exploration and categorisation of the *content* of learners’ talk. This has enabled us to address the question: “When are learners engaged with educational content as opposed to the medium of communication?” as specified earlier, and in particular the two more specific questions:

1. How can manipulation of the presented narrative within a CD-ROM impact upon educational focus?

2. How are the various system features used by learners?

There is a wide variety of work which considers the structure of the exchanges within the dialogue, the nature and quality of the argumentation, or the negotiation which occurs between participants (Ravenscroft and Hartley, 1999, Chi, 1997; Pilkington, Treasure-Jones, & Kneser, 1999; Quignard & Baker, 1999, for example). It would certainly be interesting to explore the structure of the dialogues surrounding the use of *Galapagos*, but such work has been beyond the scope of our analysis to date.

The dialogue between learners as they use *Galapagos* has been transcribed and categorised. The categories used have been carefully selected and were informed by our early observations of commercial CD-ROMs and the questions we wanted to explore here. With respect to educational focus, these categories enable us to:

- differentiate the times when learners are focusing on procedural or operational issues, from the times when they are involved in the pragmatics of answer construction and
- to differentiate the times when they are trying to construct an understanding of the underlying concepts about evolution.

In order to investigate system feature use we developed a representation: CORDFU, (described below) which enabled us to match the type of dialogue to the system feature in use at the time of that dialogue. This meant, for example, that we could see what learners were talking about when they were using the notepad or the search facility.

All coding of dialogue was completed by two researchers acting independently but using the same system of categorisation. Discrepancies were few and were discussed in order to reach a consensus about the final coding category to be used. The dialogue was categorised initially into *Non-Task*, *Task* and *Content*, each of these categories has then been sub-divided for a more detailed analysis.

1. The NON-TASK category encompasses navigational and operational talk other than that which relates specifically to using the notepad or model answer e.g. “click on one” “play” for video or audio clips. This category focuses on the use of system features and learners’ interactions with the operational aspects of the system rather than the content.
2. The TASK category includes dialogue about the pragmatics of answer construction, about getting the task done rather than what to put in the answer. For example, discussions about how and when to use the notepad e.g. “shall I type?”. The focus here is on specific software features such as the notepad and model answer. Here learners are negotiating the use of tools which should enable them to interact with the content and construct an understanding of these concepts.
3. The CONTENT category of talk includes all discussions about Darwin, the Galapagos islands and evolution, both specifically related to constructing a group’s answer and in general. The sub-categories here are of particular interest to the investigation of the role of dialogue in the acquisition of conceptual understanding and at the next level of granularity consist of talk:
    - About constructing a sub-goal: discussion of what to do next which appears to be motivated by content e.g. `“why do we want to take notes?”`

- Reactions to, descriptions of or comments about the nature of the resources or their content which contain no evidence of processing e.g. `“It’s really cool”.`
- About what the answer content should be and what they should write e.g. `“Well they are all very similar aren’t they, just with slightly different - um”.` Here the `“they”` refers to the different birds species Darwin found on the Galapagos.
- About the Model Answer e.g. `“so we have missed that massive chunk out”`

There were very few examples of instances where dialogue fell into more than one category. These were entirely restricted to humorous comments which might for example be flippant and yet relate to content.

The audio recordings were transcribed and analysed in conjunction with the video transcript data. We explored the emergence and evolution of the concepts which first appeared during learners’ experience of the CD-ROM and later in their individual audio re-tellings.

Representations of Dialogue and System Use

To aid our analysis of this large data set we produced different representations to illustrate different aspects of learner interaction (see Luckin, Plowman, Gjedde, Laurillard, Stratfold, & Taylor, 1998, for more detail about the methodology and analytical tools used). In this paper we will concentrate on just one of these analytical tools and illustrate the manner in which it helped us relate the dialogue between learners to their use of the CD-ROM. We hoped that this would aid our understanding of what it is about a CD-ROM that leads to a focused educational experience .

Chronologically Ordered Dialogue & Features Used (CORDFU)

This is a graphical representation of the path navigated through the CD-ROM by each group of users integrated with information about the category of talk which occurred between the learners when a particular CD-ROM feature was in use. This tool is particularly useful for exploring the effect of narrative guidance on navigation and the manner in which the different system features are accessed. Figure 3 illustrates part of a COR**D**FU chart.

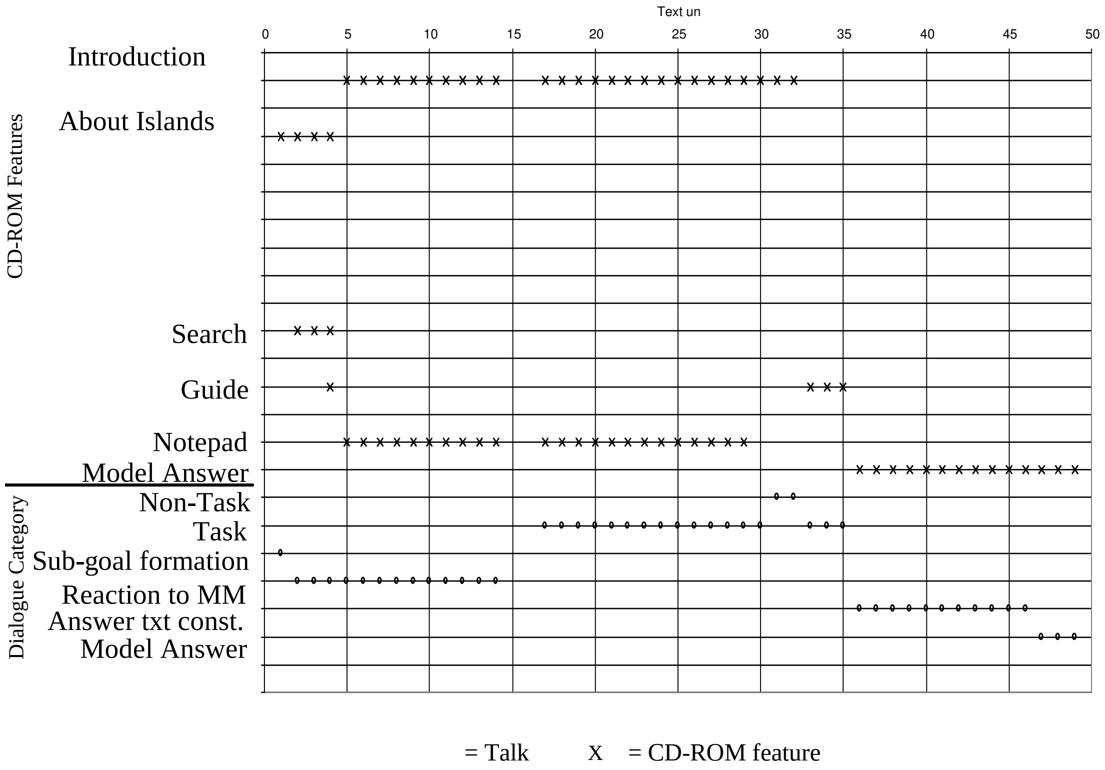

Figure 3 A section from a CORDFU chart

In Figure 3, the upper part of the vertical axis (above the horizontal line) records the different features of the Galapagos CD-ROM: the introductory section, the eight sections containing material about Darwin, Galapagos and evolution, facilities such as the search engine and tools such as the notepad. The lower part of the vertical axis (below the horizontal line) records the categories of talk. The last four of the headings i.e. Sub-goal formation, Reaction to MM, Answer text construction and Model answer are sub-divisions of the CONTENT category. Only the names of the features and categories present in the example have been included in Figure 3 to avoid confusion, all information is present during analysis. The horizontal axis records the amount of attention paid to a feature or dialogue category. The horizontal unit of measurement is a text unit which comprises up to 24 characters of dialogue text[1]. An **X** on one of the upper horizontal lines therefore indicates that one text unit worth of time has been spent with the CD-ROM feature specified. A **O** on one of the lower horizontal lines indicates that the text unit occurring at this point in the dialogue has been coded as belonging to the category specified. For each **X** recording a CD-ROM feature there is a **O** indicating the type of talk that occurred whilst this feature was in use. So, in the example CORDFU extract in Figure 3 we can see that the group f

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[1] The software used for this analysis was NU*DIST which requires all transcripts to be divided into text units in this way.

learners it represents used the notepad in conjunction with the introductory section whilst discussing their reactions to the multimedia and the pragmatics of constructing an answer to the set task.

Our rationale for the creation of the CORDFU was motivated by the need to be able to identify what sort of system features were being used by learners both when they were talking about the their answer construction task and when they were not. We wanted to build up a picture of what they were doing with the CD-ROM at particular points in their interactions.

One disadvantage to this approach, as far as analysing system feature use is concerned is that silence is not recognised. A feature may have been open on the screen and have been viewed, but not recorded on the COR**D**FU chart. This omission can however be compensated for by use of other analytical tools (Luckin, Plowman, Gjedde, Laurillard, Stratfold, & Taylor, 1998). There were in fact few instances of complete silence during our studies.

Results

The goal of our analysis was to construct an understanding of: what was happening at the system interface; what was happening between individual learners in the group; and what sort of an understanding individual learners were constructing as a result of these collaborative interactions. In addition to exploring these three aspects in their own right we also wished to unpack the relations between them; to answer questions such as: what sort of interactions occurred between learners when they were using feature X?

We therefore investigated the relationship between the content and themes within the learners' dialogue and the structures and features existing within the CD-ROM. We present the results here in terms of the three Galapagos variations. Each of the three system versions is considered as case study and the data relevant to each is discussed in terms of the two questions highlighted earlier:

1. How can manipulation of the presented narrative offered by a CD-ROM impact upon educational focus?
2. How are the various system features used by learners?

The information from the CORDFU charts for each group is used initially to discuss the general pattern of *Galapagos* use, and in particular the use of any guidance provided within the CD-ROM. A brief description of the whole interaction from which the CORDFU was extracted is included to contextualise the small section depicted in this representation. Particularly interesting sections of a groups interaction are then supplemented with other data or representations of that data.

Analysis of the individual learners' audio recordings offer indications about the relationship between the inter-group collaboration around Galapagos and each learner's individual experience. Many factors will influence both the individual learner's contribution to collaborative answer production and their subsequent re-telling (See Plowman, 1993, for a discussion of roles in the organisation of a co-authoring task.). The effects of already established peer group relationships amongst the students, as well as their own individual ability will be influential here for example. There are also strong cultural influences which impact upon both the group collaboration and upon how they recount their experience subsequently. We accept the complexities of the dynamics of peer group interaction (as highlighted Cohen, 1994 by for example) and concentrate here upon the relationships we can observe between an individual's behaviour during inter group answer production and what that individual said about their learning experience afterwards.

Before discussing the individual system variations, there are findings arising from all the user groups which are worthy of note. These are relevant to answering questions about the presented narrative and educational focus and about the use of system features. With regard to educational focus for example, the discussions conducted by all groups of learners were focused on the content of the CD-ROM to a much greater extent than in our previous pilot empirical study with commercial CD-ROMs. Within the learners' dialogues, there was twice as much CONTENT type talk as talk categorised as NON-TASK or TASK. Likewise with respect to individual system feature use: over 25% of the total discussions between learners took place when the notepad editor was open on the screen and more than 10% when the model answer had been accessed and was open on the screen. This was true in total and for each of the three system variations. Talk about navigational and operational issues (i.e. categorised as NON-TASK dialogue) for all groups occurred throughout all but one content section of the CD-ROM as learners discussed when and how to play a particular video clip for example. Discussion about how to complete the task (i.e. categorised as TASK dialogue) was however less evenly distributed amongst these same content sections.

In the following three sections of this paper we describe the way learners used and talked about each of the *Galapagos* system versions. These sections share a common structure with each one presenting:

- A section from a CORDFU representation along with a description of the *Galapagos* session for the group of learners whose interactions are represented within that CORDFU. This example is used as a focus for a discussion about how the manipulation of the presented narrative offered by a CD-ROM can impact upon educational focus.
- Discussion of the way in which groups using this system version used the CD-ROM features available to them.
- Discussion of the audio retellings for individual learners.

Linear *GALAPAGOS*

The version designed to present an easily identifiable narrative: When the material on this version is first viewed the system moves automatically between the content sections, learners can then can elect to go back to certain selected points within this presentation and from there, they can move either backwards or forwards between the different sections of content. There is no full menu or search facility and no overview of the structure of the CD-ROM.

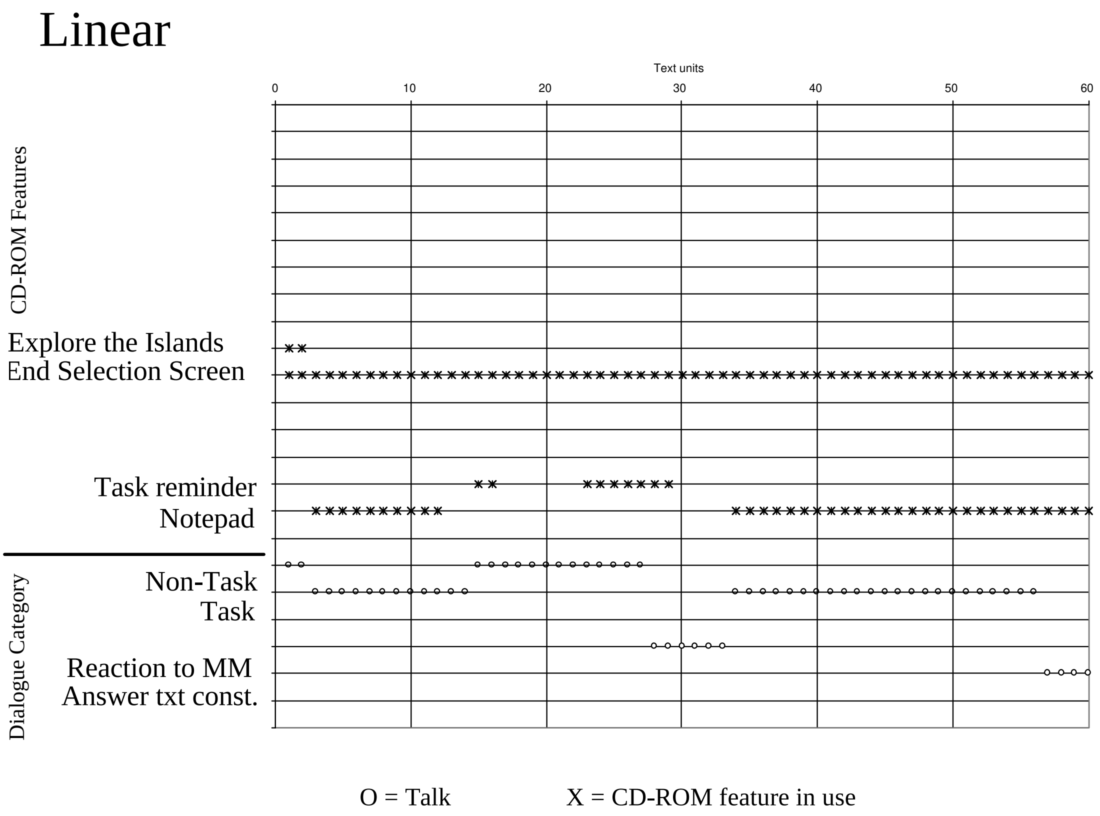

Figure 4 A section from a Linear User Group CORDFU chart

Figure 4 presents a section of the CORDFU for a Linear User group. It represents a small snapshot of one group's interactions and illustrates the initiation of answer construction in the notepad after all sections of the CD-ROM have been viewed.

The whole interaction for the group depicted in Figure 4 was as follows: The first 17. 31 minutes (47% of total system time) of activity which precede the notepad being opened for the first time consist of 4 iterations through the linear path of CD sections: twice forward and twice backward. The task is accessed briefly at 11.22 minutes and 11.33 minutes. The only task relevant conversation is about whether they want to complete an answer and how they might type into the notepad. The Task is presented to the students in the initial introduction and they access it briefly on 3 other occasions. There is an attempt to access the model answer at 16.11 minutes and soon after this (17.31 minutes) the group start to use the notepad to construct an answer. They start by looking at the task again and then work through the CD sections with the notepad until they access the model answer at 33.24 minutes. During the time between 33.24 minutes and the end of the session at 37.51 minutes they read the model answer and discuss what they can add to their notepad answer.

The CORDFU chart in figure 4 is extracted from the period between 17 and 19 minutes into the session.

Navigation with this version of the CD-ROM was limited with *back* and *forwards* buttons on the toolbar being the only type of control that was always available to users. In fact, despite the availability of these controls, none of the *Linear* user groups altered the order of presentation of the CD-ROM sections until they had viewed them all at least once. All of these learners also viewed all sections of the CD-ROM before they started to construct an answer. Once answer construction started, reference back to the content sections of the CD-ROM was rare. One group, for example, did not refer back to any content section until they had written enough in the notepad to access the model answer. All *Linear* groups entered sufficient text in the notepad to allow access to the model answer and evidence from the records of text entered in the notepad indicates that all made subsequent revisions to their text.

Discussion about the process of task completion (i.e. categorised as TASK dialogue) was rarely conducted whilst the content sections were being viewed. In fact, the co-ordination of this type of discussion with the use of a content section of the CD-ROM was predominantly conducted at two points in time: the first content section viewed by a group and the content section viewed immediately before starting to construct an answer. Likewise**,** CONTENT talk was less prevalent whilst learners were viewing the content sections of the CD-ROM. In particular, as with the TASK talk, there were instances of CONTENT talk occurring most prolifically when the first and, in particular, the last CD-ROM content section before answer construction, were on screen. In fact, for one *Linear* group CONTENT talk only occurred during these two CD-ROM sections. Clearly, learners using this system manipulation did not discuss the content whilst they viewed the content sections of the CD-ROM, in fact their conversations at this stage were minimal.

Galapagos Feature Use.

As we have already noted, Linear system users did not alter the order in which material was presented to them until they had seen it all at least once. However, there was considerable discussion when they reached the end of the CD-ROM content sections and were faced with a selection screen (Figure 4 illustrates this moment for one group). This screen offered them a limited range of alternatives: to move back to the previously viewed content sections at restricted, pre-specified points, or to move on to constructing an answer, it was a type of rather limited menu. The *Linear* users talked more about how to use the notepad to construct an answer whilst accessing this screen than at any other point, with the exception of using the Notepad itself. When the strength of the presented narrative reduced and these learners started to take more control over their route through the material, they started to discuss the content and its relevance to their answer. This is illustrated in Figure 4 above and can be seen in the following dialogue extract which is taken from a Linear group who have reached the end of the CD-ROM content sections:

Speaker	Comment
2	You have got to go to answer
1	What this one, oh all right then
3	(*reading aloud from screen*) "You must write an answer of at least 50 words in the notepad before looking at the model answer." Right OK.
1	You can write it Joe
2	You use the..
1	Yeah
1	Go to notepad

Evidence presented earlier in this paper suggested that the macro-structure of the *Linear* version encouraged learners to view all sections of the CD-ROM and so experience the 'whole story' before they started constructing their own answer. Evidence from further analysis of the notepad answers suggests that learners had adapted, though not copied verbatim, some recognisable material from the CD-ROM. The following extract of activity provides and example of this sort of text production.

Time	**Notepad text**	**Activity**
17.31		Notepad opened first over the top of the end selection screen. No text is entered.
18.06		Task opened again. Task closed. Notepad opened over end selection screen again.
18.28	"The Galapago	text entered: Notepad moved down so that the word Galapagos at the top of the end selection screen can be seen.
18.31	"s. islands have lots of different wildlife"	Text entry: long pause Notepad closed. CD Section 2: "About Darwin" video started and then the notepad opened over the top of this screen.
20.53	"wildlife/wild/wildlife"	text entry: "About Darwin" sequence allowed to run and text added:
	"Darwin came to island on British boat. darwin was curious of different wildlife. especially birds."	

The accompanying audio transcript for the video which makes up this part of the “About Darwin” content material is actually:

“Darwin visited the Galapagos islands in 1835. He was the first person to spot the peculiarities of the plants and animals . On the beaches iguanas were grazing on the seaweed and were happy to live on the salt water, Giant tortoises, of a kind not found within thousands of miles of the islands. Seabirds he readily recognised in shape and form as cormorants, which had lost the power of flight. The royal navy survey ship, the HMS Beagle brought Darwin to the islands.

Individual Learners

In the linear version of *Galapagos* two student’s in each of the four groups dominated the production of the answer, whilst the third student either assumed the physical production role (typing) or remained quiet for the majority of the session. In two of these groups, one student took greatest control overall and produced the answer largely by himself, fielding comments from colleagues. These dominant individual’s personal audio account of the session tended to be less full (number of words) and less factually correct than the students who had played a less dominant, but active role in the group. The least dominant individual in *all* cases produced the poorest re-telling, in comparison to the other members of that group (i.e. shorter, with less focus on and accuracy in the factual questions).

The extracts in example 1 below illustrate the different types of story learners produced. The first account provided information about the CD-ROM although there was little evidence about the learner’s conceptual understanding, about the temporal order of the group’s activity or the process of using the CD-ROM. The second account is a descriptive story of the learner’s experiences with the CD-ROM, but it reveals very little about her underlying conceptual understanding of the task she was asked to complete. This type of narrative about the process of using the CD-ROM was more prevalent amongst the linear system users which offers an indication about the possible impact of the presented narrative upon learner reflection. Such an indication may be useful in the design of future research tools and would certainly be an interesting question to explore with a larger user group.

Example 1. Extracts from the audio responses to the question: Imagine your friend couldn't get to today's lesson and asked you to fill them in on what they've missed. Try to give them a good idea by describing the lesson in plenty of detail.

Dominant Individual:

Basically we were learning all about the genetic variation in a species called finches, which is a type of bird. They range in size from, you know, very small to great big finches, and they eat a variety of foods all the way from cactus leaves to you know, the small insects and creatures. Um - the islands in question were first discovered by Darwin and through his experiments into natural selection and the development of the species, that's why it's you, called Darwinian islands.

Less Dominant Individual (also rated ‘less able’ by the tutor)

We entered the programme and we went through the introduction, where we were told about some animals and Darwin's islands. We covered the areas of where we were told about, um, climates and breeds of finches and - we discovered the Latin names for a lot of birds, 13 birds, and we were given a brief outline of how they, well, what their habits are - We were shown a map of the Galapagos islands and we were able to click on an island and a screen came up showing us what island it was, and what birds were found on it.

Resource Based Learning *GALAPAGOS*

In this version learners have free access to all sections of the CD-ROM through a menu and free text search facility. It was designed to reflect the encyclopaedic nature of the existing commercially available CD-ROMs we had observed in our pilot studies of classroom use.

The presented narrative and educational focus

Figure 5 presents a section of the CORDFU for a RBL User group. It represents a small section of one group’s interactions and illustrates, in particular:

- The use of the menu to guide navigation through the content.
- The co-ordination of talk about answer construction with use of content material, both with and without the notepad.

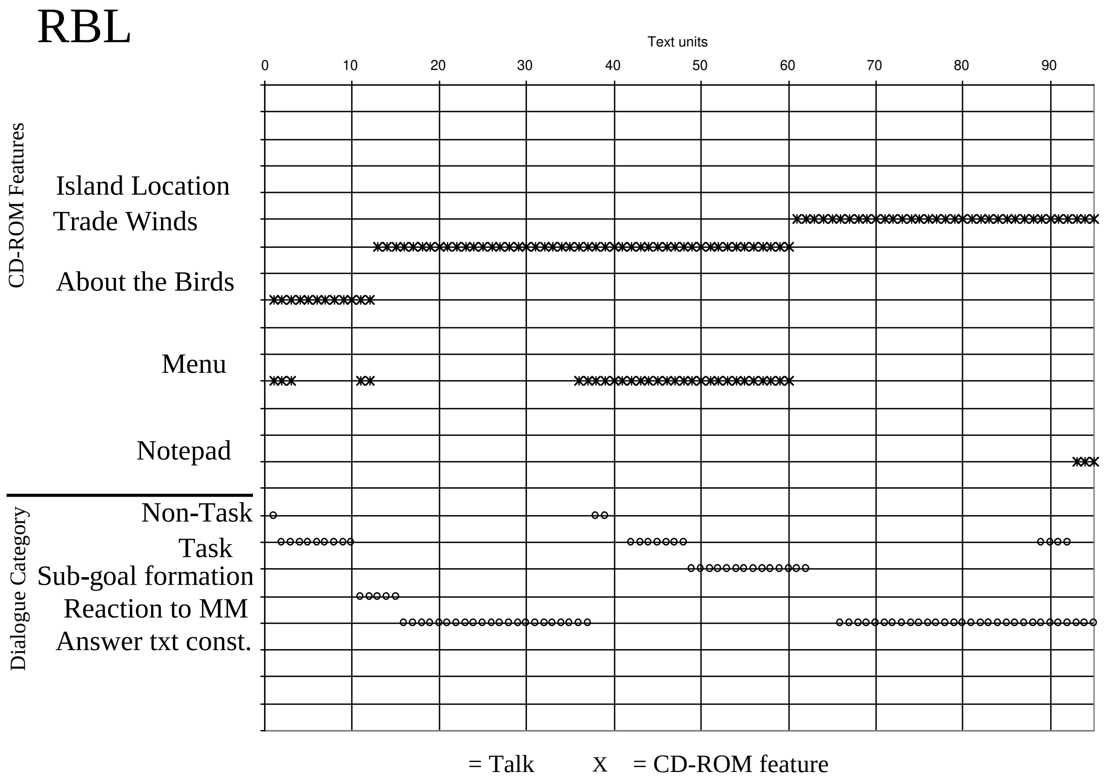

Figure 5 A section from a RBL User Group CORDFU chart

The whole interaction for the group depicted in Figure 5 was as follows: The first 4.58 minutes (13% of total system time) of activity which precede the notepad being opened for the first time consist of menu and search engine use, plus viewing the first two CD sections. The task is presented to the students in the initial introduction and is re-accessed first at 8.17 minutes and on three other occasions at: 12.29 minutes, 15.29 minutes, 15.5 minutes. There is no discussion of the task or what they need to do. Between opening the notepad and accessing the model answer at 30.51 minutes (73% of total system time) activity consists initially of using the search engine which directs the group to section 8 of the CD-ROM only. About 50% of the talk is specifically relevant to the completion of the task. Subsequently (12.47 - 30.51 minutes) activity consists of using the menu to move to different CD-ROM sections and then entering information in the notepad. The task is consulted three times during this latter phase. During this period the talk when the notepad is being used is almost entirely task specific, when the notepad is closed there are sessions of talk which is about the content of the CD-ROM, but little which is specifically relevant to the task There is only one attempt to access the model answer at 16.53 minutes. After the model answer is opened at 30.51 minutes (14% of session total) activity consists solely of notepad and model answer usage. The dialogue is almost entirely about the task, the model answer and how the group's notepad answer might be altered. The CORDFU chart in figure 5 is also extracted from the period between 17 and 19 minutes into the session

The RBL groups adopted a different approach to navigating through the CD-ROM. They used either the search or the menu facility as a central spine around which to manage navigation to other sections of the CD-ROM. Learners did not necessarily wait until all sections of content material had been viewed before they started to construct an answer, in fact not all groups viewed all the content available before they finished their session. All groups accessed the model answer, although examination of the notepad records reveals that they did not all make subsequent revisions.

In contrast to the Linear users, the RBL groups did talk about the content whilst they viewed it and they also frequently referred back to other material on the CD-ROM whilst they constructed their answer. The following dialogue extract is taken from a RBL group who have started to write their answer and have now started to review the section of the CD-ROM about the location of the Galapagos islands. It illustrates that there is content focused conversation between learners during this activity.

Speaker	Comment
1	the islands have different relief in the middle"
2	if you think about Japan, all the people live around the edges because its flat and I would have thought it would be the same on the islands
3	there are no people on the islands

2	animals
3	if all the animals lived around the edges there
2	- live in the mountains?
1	relief - yeah or no?"
2	they have got things like goats in the mountains

Galapagos Feature Use.

The menu was used to guide navigation through the CD-ROM. However, investigation of the dialogue reveals that it rarely accompanied discussions informed by the need to find specific information to complete the answer. The extract below is symptomatic as it occurs while the users are interacting with the menu and after they have attempted, unsuccessfully, to access the model answer. The model answer can only be accessed when 50 words of text have been entered in the notepad, prior to this being the case the computer emits a beep.

Speaker	Comment
2	If you look at model answers it might not beep again
3	Model answer - we have already been there
2	Yeah but it might not beep again
1	No, what haven't we done?"
3	go to the answers
2	no, we haven’t got enough information yet
3	Location
2	We know where it is - its in the sea
1	no

The notepad was used throughout all RBL groups’ sessions rather than simply towards the end. Text was also entered in the notepad before learners had viewed all the content. The text itself was often entered in small sections, none larger than two short sentences with frequent instances of text being copied verbatim from the screen or audio. There was a cut and paste facility available within the audio transcripts feature, although not for other screen text. However, despite the availability of such a feature and students’ desire to complete copy and paste type activity, none of the students used it for this purpose. The extract of notepad activity presented below illustrates the match between the system audio for a video clip and the text typed in to the notepad by one group of RBL learners.

TIME	NOTEPAD CONTENTS	DIALOGUE -	SYSTEM AUDIO

		USER 1 what?	.. like Madagascar has become separated from a continent and the plants and animals on it become a sort of nature's lumber room The other sort, newly formed islands like Galapagos, initially have no animals or plants on them, and they acquire, by a random process, a selection from a neighbouring continental land mass.
		USER 3 didn't you see all the notes that went up?	
		USER 1 uh huh	
5.09	Galap	USER 3 Its a new islands"	
		USER 1 yeah	
		USER 3 How do you spell it - GALAP	
5.17		USER 2O-GA	
		USER 3 Galapogos - there you are. Galapagos	
	ogos	USER 2 it don't look right	
5.25		USER 3 Oh well.	
	islands are	USER 2 Galapagos	
		USER 3 I know how to spell this"	
5.45		USER 2 They did, they were newly formed	
6.05			
	newly formed islands	USER 1 newly formed yeah	
6.07		USER 1 close notepad	

Individual Learners

It was difficult to map a relationship between inter-group activity and the subsequent re-tellings of the RBL learners. In two of the groups one individual took control for answer production. The audio retellings from individuals in one of these groups are all limited, in the second of these groups the dominant member produces a short but largely factually correct audio account whilst the others state very little. In a third group, two members of the group produce the answer, but the quietest student during the session produces the fullest audio session, a variation on what happened with the linear version. In the last group, all students work together during the session, discussing all points. The student who constantly questions the task admits to being confused in her audio session, which is the weakest of the group, but has contributed to the production of the group answer, largely through repeated questioning about the task itself. The notepad answers these groups constructed were acknowledged by the teacher to be not particularly good, and in one case, an individual student from the group of most able students also acknowledged this. The consistency which can be found within this group is in the correlation between individual student ability and the ease with which they make meaning of the task: more able students produced fuller and more factually accurate audio re-tellings.

Guided Discovery Learning *GALAPAGOS*

In this system version the menu is expanded into a textual guide which breaks the initial task down into sub-tasks and suggests the relevant sections of the CD-ROM to access for information about these sub-tasks. In addition, as with the RBL version, learners have access to a free text search.

The presented narrative and educational focus

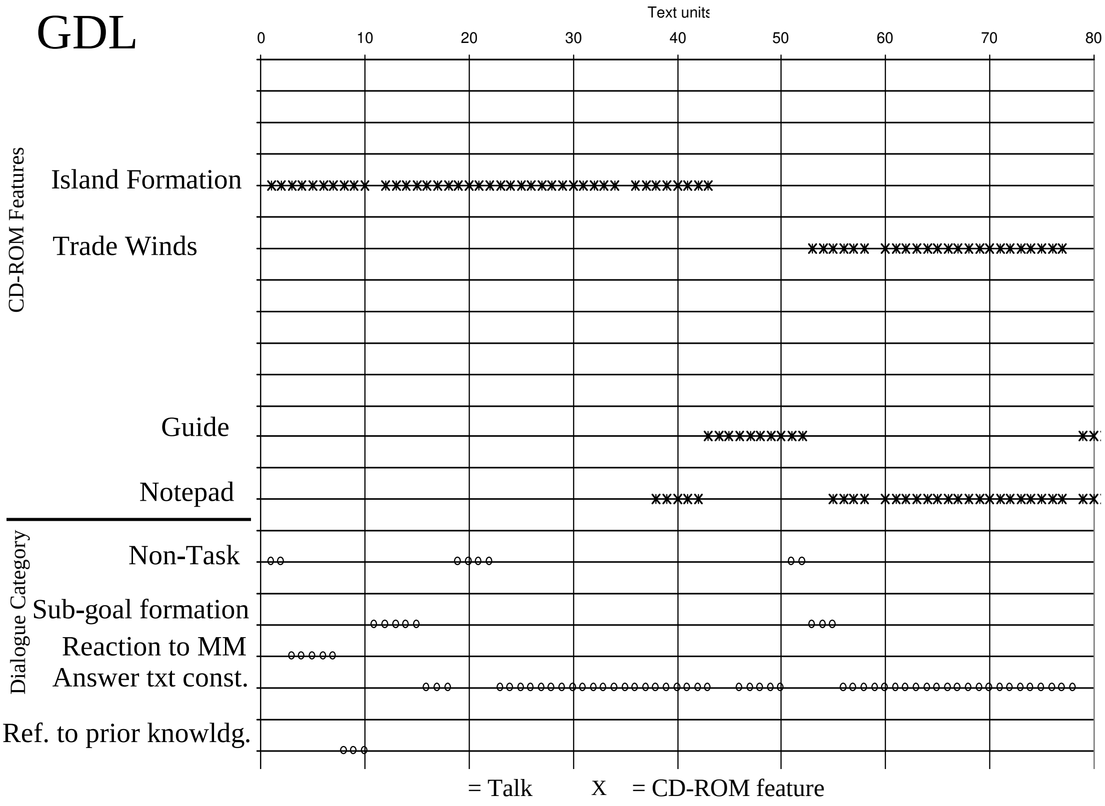

Figure 6 A section from a GDL User Group COR**D**FU chart

Figure 6 presents a section of the CORDFU for a GDL user group. In this section the Guide is being used between two sections of content material: “Island Formation” and “Winds and Water”. Unusually, there is no TASK type talk whilst the Guide was in use, although there is evidence of CONTENT talk whilst both content sections alone are on screen and whilst the notepad is also in use.

The whole interaction for the group depicted in Figure 6 was as follows: The first thing this group do after the initial introduction (which includes the specification of the task) is to access the task again and discuss what it is they have got to do. They then return to the introduction which involves hearing the task again. Between 2.19 minutes and 14.37 minutes (34 % of the total session time) the group starts to construct a notepad answer. They access the guide and through this facility they move on to content section 8 of the CD-ROM, they open the notepad and then section 2 of the CD. Initially (2.19 - 5.29 minutes) talk is about what completing the task involves. This is followed by a move back to the introduction and therefore another experience of the task. At 4 minutes the search engine is used and section 2 of the CD-ROM is accessed. Activity between 4.09 and 14.37 minutes (29 % of total session time) activity consists of alternating between section 1 of the CD-ROM and the notepad, with one look at the task as well. As they watch section 1 of the CD-ROM, they start to type into the notepad and the discussion is about what they should write, picking up points from the audio track. At 14.54 minutes they go back to the introduction again and then to the task and in this way they hear the task twice. At 14.54 minutes the search engine is used to reach section 7 of the CD-ROM. Discussion is about how the section on the different birds relates to the task . The notepad is not used after this, but is opened again at 19.09 minutes after the guide has been used and section 2 of the CD viewed. They talk about the importance of the Galapagos being an island and how this relates to the task. Until the model answer is opened at 28.04 minutes activity consists of using the guide to access sections 3, 5 and 6 of the CD-ROM, and further completion of an answer in the notepad. About 50 % of the talk is about the completion of the task. The features of the CD-ROM section and their relationship to the model answer are discussed. Once the model answer is accessed section 2 of the CD-ROM is opened and some revisions made to the notepad. The CORDFU chart in figure 6 is extracted from the period between 23 and 25 minutes into the session

In contrast to the users of the *Linear* version, no *GDL* groups viewed more than half the available CD-ROM sections before they started to enter text into the notepad. They used the text-based Guide to direct their access to the rest of the material. The *GDL* learners discussed content relevant issues whilst accessing this on-screen Guide but the Guide was really a focus for TASK talk, with CONTENT talk being slightly less prolific. There was again, as with the RBL groups, a tendency for the text to be entered in small sections with reference back to content material on the CD-ROM. In line with the *Linear* users, all *GDL* groups had viewed all sections of the CD-ROM, except the model answer, by the time their own answer was complete.

Galapagos Feature Use.

Evidence from analysis of the answers constructed in the notepads suggests that , like the RBL groups, some of the *GDL* users took material verbatim from the CD-ROM : from audio and video tracks or from text on the screen (again, like the RBL group they made no use of the cut and paste facility). The following dialogue occurred whilst a group of *GDL* learners are using the on-screen notepad as a ruler to underline bullet points of information about islands. They copied each of the bullet points into the notepad, but as was typical of talk when text was being copied in this way, they did not discuss the content.

Speaker	Comment
2	*(pointing at screen)* - we can put that over there
3	that’s one up there - (*reaches for keyboard)*
1	you want to write it down?
2	I can't see it - move it across - there it is. *starts to type*

3	(*to themselves*) I am going to move up
2	you do some (*pointing to 3)*
3	I can't type - I can't type at all
2	I can't see (*clicking with mouse)*
1	You sure we have to write these down?
2	We are meant to be taking notes
1	*(Moves mouse)* - you want to do anymore?
2	We might as well do the last one

The model answer was a feature designed to help motivate and support learners. We have already seen reference to it in the dialogue extract from the RBL group. They were trying to decide whether to try and access it having failed once already. However, we wanted to know what learners talked about when they did succeed in opening the model answer: did they use it to revise their own text? The pattern of the dialogue for a time at which a group of *GDL* system learners are using the model answer to inform revisions to their own text is shown in the COR**D**FU chart in Figure 2 (used for the initial description of the CORDFU) and in the following dialogue extract (this matches the interaction in Figure 2 from just after point 40 on the horizontal axis of the COR**D**FU chart.).

Speaker	Comment
1	well I just put that
2	did you just put that?
1	yeah
2	well done
2	that’s because -
1	we put the strong winds and ocean currents - it is most likely that the birds arrived in the islands via weed rafts - didn't know that - once there they survived without any human intervention - oh!
2	*(reading aloud)* - :so we have missed that massive chunk out -

This illustrates the use of the model answer in prompting the group to revise their own answer. They recognised the information on *strong winds and ocean currents* in the model answer as being present in their own answer, but note that they have missed out something important about how the birds arrived. The model answer was intended to prompt reflection and revision, but it is only through looking at both the evolving answers in the notepad and the dialogue when the model answer is being used that we can start to see that our intended use is in line with learners’ actual use of this feature in this example.

Individual Learners

Learners from three out of the four groups who were using the GDL version of Galapagos produced correct and complete answers in their audio re-tellings. In addition, and in contrast to the Linear and RBL groups there were no instances in which one individual took control and dominated the rest of their group. There were occasions when two of the three individuals were more active and there were examples of all members working together and contributing to the answer. Not all the students who had little prior knowledge were able to construct the top-level answer in the notepad with the GDL version collaboratively, but they were all able to recall some factually accurate material when required. The Linear version of *Galapagos* was the only one which guarantees that all sections of the CD-ROM content would be shown, and yet the GDL learners were more likely to attempt to answer all questions as illustrated in the transcript of one such learner below:

Question A: Why are the islands interesting to biologists?
Answers:

GDL Group Member

Islands are interesting to biologists because they are like on their own and they've got, like, you can see what's, what's actually in them and stuff like that.

Question B: Why were the Galapagos Islands interesting to Darwin?
Answers:

GDL Group Member

They were interesting to Darwin because they were quite new to like the world because they had only been produced over a certain amount of time.

Question C: What is a trade wind?
Answers:

GDL Group Member

A trade wind is a wind that blows to 10 - 20 knots, um and it blows from South America across the Galapagos Islands.

Question D: Where are the Galapagos Islands?
Answers:

GDL Group Member

The Galapagos Islands are on the equator to the West of um South America.

Discussion

The Galapagos study was designed to help us clarify our understanding of how learners use multimedia and how system design can impact upon learner experience. We have presented detailed case studies of groups of users interacting with the three versions of the *Galapagos* CD-ROM. The central question we set out to explore was: "When are learners engaged with educational content as opposed to the medium of communication?". We considered this question from two perspectives: How can manipulation of the presented narrative within a CD-ROM impact upon educational focus, and how are the various system features used by learners?

In this discussion we present a summary of the implications of this study for the design of MILEs and for future research in this area. In all 3 versions of Galapagos there are:

1. Sections of content material each of which has its own micro-narrative, some stronger than others
2. Some guidance features which enable users to determine their own trajectory through the CD-ROM: the Menu, Guide, Linear End Selection screen and Search system facility.
3. Some answer construction tools or features designed to enable users to co-construct an answer: a notepad, a model answer, a task and transcripts.

The different variations to the strength of the narrative presented within the CD-ROM have engendered different approaches to the task learners were asked to complete. The conversations between learners have illustrated variances in the focus of their discussions. The nature of these variations has lead to the proposal that it is not merely the presented narrative within the material that is influential, but also the relationship between this presented narrative guidance and the system features that support the answer construction process. Investigations of the use of system features has confirmed the usefulness of elements such as the notepad and model answer. It has also offered some surprises: the importance of the Linear End Selection screen for example.

In *Galapagos* the guidance features plus the strength of the presented narrative help users make connections and build links between the task they have been set and the individual elements of content which they need to pull together into an answer. To ensure that learners capture a coherent narrative about species variation they need to co-ordinate their use of the features which offer them guidance through the content (including the structuring within the content itself) with their use of features designed to aid the process of answer construction. In the groups we observed the extent to which the guidance offered by the particular version of *Galapagos* helped to build connections between answer construction tools and Content varies between the three versions of *Galapagos*.

- Linear users have a paucity of guidance outside that presented and controlled by the system. Their control over what is available to them is also incomplete. For example, when they have seen all sections of the content available they are offered a meagre selection screen again which allows them access to certain points in the macro-narrative whereafter the system picks up control.
- For RBL users, both the search and the menu provide a link to both Content and answer construction tools and there are many examples of both facilities, but predominantly the menu, being used as a ‘springboard’ to both sorts of feature (i.e. both Content and answer construction tools). The menu provides free access to all sections of the CD-ROM and requires learners to make an active selection but it gives no explicit indication as to the way these individual sections might slot together to answer the task. This is fine for confident and able learners who can piece things together and construct threads to their existing knowledge.
- The GDL learners, like the RBL groups have two means of free access to all parts of the CD-ROM: the guide and search. Both act as effective links to both content answer construction tools; this is particularly true for the guide. Unlike the menu, the guide offers explicit information about how individual content can be pieced together into an overview which is focused on the task. Users have to actively select a guide and then a section of content from that guide. However, also unlike the menu, the guide occupies the whole screen which means that learners cannot for example, keep sight of the overview and the content at the same time as they are using the notepad

In addition to informing the production of guidelines for designers, our analysis has also highlighted potentially fruitful foci for future research. For example, the value of the notepad in promoting content related talk and in prompting learners to discuss the practicalities of completing their task. *Linear* users in particular don’t appear to talk about either the content or the practicalities of answer construction during much of the time when they access the content relevant sections of the CD-ROM. In addition, there is some evidence to suggest that they use the meagre menu capabilities of the selection screen available at the end of their first pass through the content sections as a point of focus for discussing the practicalities of completing the task. This suggests that a useful avenue of enquiry would be into the possibility that learners find some information about the macro structure of the material available to them useful in order to prompt discussion about the practicalities of constructing an answer. The nature of this overview might be further informed by the different types of talk that occurred when the menu and the guide were in use. The menu was rarely accompanied by discussions about what sort of information the group should be trying to find for their answer. By contrast, the guide was accompanied by both TASK and CONTENT categories of talk.

At the start of this paper we portrayed the nature of an effective Multimedia CD-ROM as one which provides "*global coherence within the macro-narrative, local coherence within the micro-narrative and a network of potential links between the two which enable learners to focus on content, maintain a clear goal and construct a personally meaningful understanding of the underlying concepts*." Our study of learners' talk whilst using *Galapagos* has been important in helping us identify this sort of experience. The following dialogue occurs when a group is about one-third of the way into their session. They have already constructed quite a long answer in the notepad, they are all actively contributing to the answer and focused on the content.

Speaker	Comment
1	Right, last little bit - what is it?
3	The study of these gives us a clue as to the forces of evolution - which is what the task was set up to be
1	So remember that - the study of the......
3	Right anything else
2	Stop, look
3	Reads aloud *(mutters)* Gives us a clue
2	As to the forces of evolution
1	As to how, as to the forces of evolution - As to .... we've made very long notes

When using a MILE learners should take some control for the construction of their own goals and sub-goals, and be able to interact with the content. Different abilities and types of individuals within the group will be more or less able to do this and again, the nature of the guidance provided by the system will influence which links are built between the content within the media and the answer construction process. In addition to paying attention to this interaction between guidance and answer construction, the design of interactive multimedia might be improved by attending to *narrative control*. The appropriate degree of narrative control over the sequence of events and activities needs consideration to ensure that it will match the needs of different students:

- full ‘program control’, using a default sequence with optional access to resources will tend to usurp control from the learners to the extent that they play no part in narrative construction at the appropriate level, remaining focused on the detail of the resources;
- full ‘learner-control’, where learners have free access, at all times, to all the resources, together with the choice of a Notepad and Model Answer to assist their narrative construction, risks an incomplete coverage of key material, and, without the Guide, localised attention to resources, rather than the higher level account, as they construct their narrative;
- ‘shared control’, where learners are repeatedly required to choose between the sub-goals for investigation, and the use of a Notepad or the Model Answer, will assist learners in reflecting on their findings, and articulating of their account of it.

Concluding Remarks

We set out to explore what might account for the lack of educational focus we had observed when learners were using multimedia CD-ROMs. Of particular interest was the relationship between the guidance within the structure of the CD-ROM and the nature of the interactions learners experienced. Through the development and evaluation of *Galapagos* we have been able to manipulate the guidance offered to learners within the macro and micro narratives of the multimedia, and through design features such as menus, guides and search tools. We have been able to observe the impact of these manipulations on the learners experiences with the CD-ROM and in particular their use of the facilities it provides to help them construct an answer to the task they have been set. This has enabled us to formulate ideas to inform the way CD-ROM material might be better designed to assist learners in their construction of personal meaning. We had also hoped to clarify our definition of Narrative within the context of MILEs. Certainly the validity of the differentiation we drew between the ‘designed-in’ narrative and the narrative as perceived by learners has been confirmed by the different learner experiences that occur when learner are offered the same resources.

As part of a special issue about the use of educational dialogue analysis this paper also offers an approach to the use of dialogue analysis and examples of its value to the enterprise of analysis. The COR**D**FUs showed when and how often groups accessed content sections of the CD-ROM and system features. It also indicated what learners were talking about when each type of resource was accessed. Without doubt this has enriched our evidence for system re-design and also indicated directions for further exploration.

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References

Bolter, J.D. (1991). *Writing Space: the Computer*, Hypertext and the History of Writing. LEA, Hillsdale, NJ.

Chi, M. T. H. (1997). Quantifying qualitative analyses of verbal data: A practical guide. *The Journal of the Learning Sciences*, 6 (3), 271-315.

Cohen, E. (1994). Restructuring the classroom: Conditions for productive small groups. *Review of Educational Research*. 64(1), 1-35.

Crook, C. (1994). *Computers and the collaborative experience of learning*. Routledge. London.

Clanton, C., Iannella F. & Young E. (1992). Film craft in user interface design. Tutorial Notes, CHI'92, Monterey, Ca.

Dillenbourg P., Baker M., Blaye A., & O'Malley C. (1995). The Evolution of research on Collaborative Learning. In P. Reimann & H. Spada (Eds.), *Learning in Humans and Machines* : Pergamon.

Guzdial, M., Kolodner, J., Hmelo, C., Narayanan, H., Carlson, D., Rappin, N., Hubscher, R., Turns, J., & Newstetter, W. (1996). Computer support for learning through complex problem solving. *Communications of the ACM, 39*(4), 43-45.

Landow, G. (1992). *Hypertext: the Convergence of Contemporary Critical Theory and Technology*. Johns Hopkins University Press, Baltimore.

Laurel, B. (1993). *Computers as Theatre*. Addison-Wesley, Reading, Mass.

Luckin, R., Plowman, L., Gjedde, L., Laurillard, D., Stratfold, M., & Taylor, J. (1998). An Evaluator's Toolkit for Tracking Interactivity and Learning. Innovation in the Evaluation of Learning Technology. M. Oliver (Eds.) Latid, London. Pp. 42-64.

Luckin, R., Plowman, L., Laurillard, D., Stratfold, M., & Taylor, J. (1998). Scaffolding learners' constructions of narrative. Proceedings of the International Conference of the Learning Sciences. A. Bruckman, M. Guzdial, J. Kolodner & A. Ram (Eds). AACE, Charlottesville. VA.

McKendree, Jean & John Mateer (1991). Film techniques applied to the design and use of interfaces. In Proceedings of the IEEE Twenty-Fourth Annual Hawaii International Conference on System Sciences, (pp.32-41). IEEE, NY.

Murray, J. (1997). *Hamlet on the Holodeck. The Future of Narrative in Cyberspace*. Free Press, NY.

O'Donnell, J. (1998). *Avatars of the Word: From Papyrus to Cyberspace*. Harvard University Press, Cambridge, MA.

R. M. Pilkington, J. R. Hartley, D. Hintze and D. J. Moore, Learning to Argue and arguing to learn: An interface for computer-based dialogue games. *Journal of Artificial Intelligence in Education*, 3(3), 1992, pp. 265-295.

Pilkington, R. M, Treasure-Jones, T, & Kneser, C. (1999). Educational Chat: Using Exchange Structure Analysis to Investigate Communicative Roles in CMC Seminars. Paper presented at C-LEMMAS, Roles of Communicative Interaction in Learning to Model in Mathematics and Science, EU funded TMR Conference, Ajaccio, Corsica.

Plowman, L. (1993). Tracing the evolution of a co-authored text. *Language and Communication* 13 (3) pp.149-161.

Plowman, L. (1996). Narrative, Linearity and interactivity: making sense of interactive multimedia. *British Journal of Educational Technology*, 27(2), 92-105.

Plowman, L., Luckin, R., Laurillard, D., Stratfold, M., & Taylor, J. (1999) Designing Multimedia for Learning: Narrative Guidance and Narrative Construction. In the proceedings of CHI 99. Pittsburgh, PA USA. pp 310-317.

Quignard, M., & Baker, M. (1999). Favouring modellable computer-mediated argumentative dialogue in collaborative problem-solving situations. In Lajoie S & Vivet M. (Eds.) Artificial Intelligence in Education: Open Learning Environments : New Computational Technologies to Support Learning, Exploration and Collaboration. (Proceedings of the 9th World Conference of the Artificial Intelligence in Education Society), Amsterdam: IOS. (pp129 - 136).

Ravenscroft, A., & Hartley, R. (1999). Learning as Knowledge Refinement. In Lajoie S & Vivet M. (Eds.) Artificial Intelligence in Education: Open Learning Environments : New Computational Technologies to Support Learning, Exploration and Collaboration. (Proceedings of the 9th World Conference of the Artificial Intelligence in Education Society), Amsterdam: IOS. (pp 155 - 162).

Roschelle, J. (1992). Learning by Collaboration: Convergent conceptual change. *Journal of the Learning Sciences, 2*, 235-276.

Scardamelia, M., & Bereiter, C. (1996). Student communities for the advancement of knowledge. *Communications of the ACM, 39*(4), 36-37