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Between the lines: documenting the multiple dimensions of computer-supported collaborations

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Abstract

This paper discusses the development of a documentation technique for collaborative interactions. We describe the original version of the technique as used for a single learner collaborating with a software based learning partner; the second generation of the technique, which required adaptation for application to the analysis of group use of multimedia; and finally the current variation, which is being used to record young children using digital toys and associated software. Particular attention is paid to the way in which the original approach has been adapted in order to accommodate learning contexts that involve technology beyond the desktop computer. We explore some of the challenges these different learning situations pose for those involved in the evaluation of collaborative learning and suggest that tried and tested techniques can be adapted and re-used, provided that the foci of interactivity are clearly specified and the appropriate data sources identified.

Keywords: Cooperative/collaborative learning; Evaluation methodologies; Human–computer interface; Interactive learning environments; Multimedia/hypermedia systems

1. Introduction

When we consider the possibilities for the design and evaluation of Computer Supported Collaborative Learning (CSCL) we probably constrain the CS in CSCL to situations in which learners, or groups of learners collaborate with each other around a single computer, across a local intranet or via the global internet. We probably also consider situations in which the computer itself acts as a collaborative partner giving hints and tips either with or without the addition of an animated pedagogical agent. However, there are now many possibilities for CSCL applications to

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be offered to learners through computing technology that is something other than a desktop computer, such as the TV or a digital toy. In order to understand how such complex and novel interactions work, we need tools to map out the multiple dimensions of collaboration using a whole variety of technologies.

In this paper we discuss the challenges posed to the CSCL researcher by the changing use of technologies for collaboration. We discuss three different technological contexts and the evolution of a documentation technique that we have developed during our empirical investigations of such collaborative learning situations. It is this documentation technique that forms the focus of this paper, rather than the technologies involved in the collaborative interactions being recorded. The documentation was originally used in a traditional, single learner context and further developed for application in CSCL contexts involving groups and novel technology. We describe each of the three technologies that form the CS in the CSCL contexts to which we apply our documentation. We then present three short case studies: one for each of the contexts described. Each case study discusses the empirical evaluation of the particular CSCL context and gives an example of our documentation of users interacting and collaborating with or through the technology. The technique discussed is one approach and is offered, along with suggested adaptations to motivate discussion and further work. Through this paper we suggest that tried and tested techniques can be adapted and re-used, provided the foci of interactivity are clearly specified and the appropriate data sources identified. We discuss the benefits of our approach and suggest that we need to constantly evaluate and extend the documentation techniques we adopt as well as the technologies we use to engendered collaborative learning.

2. Three types of CSCL contexts and technologies

2.1. The ecolab software

The Ecolab is a software environment with an underlying design metaphor of an Ecology Laboratory into which the child (aged 9–11 years) can place different organisms and with which she can explore the relationships that exist between them. The overall motivation that is presented to her is that she should explore which sort of organisms can live together and form a food web. The software is now in its second generation in the shape of Ecolab II.

The Ecolab operates in two modes: *build* and *run* and is controlled by the child's mouse driven commands. *Build* mode allows the child to construct her mini world of plants and animals by adding those of her choice. When switched to *run mode* she can activate these organisms, for example, the child can specify that a sparrow hawk will eat a thrush. When these actions are activated their effect can be observed. If the action specified, is possible it will occur and the changes can be observed. If the action is not possible the child will be guided towards a possible alteration so that the effects of the selected action can be observed. When a learner interacts with the Ecolab she does not need to deal with the full complexity of possible food web inter-relationships. The learning environment provided by the Ecolab can operate in three several phases of relationship complexity. This means that not all the possible methods of activating the Ecolab are available all the time. In phase one, which is the simplest, the relationships which can be formed by the Ecolab objects are only those between a food and a feeder: the *eat* or *eaten by* relationship. The later phases allow the formation of food webs and relationships between all the different members of the web. The system can switch between these phases from the less to the more complex, or in reverse from the more to the less complex. The activities available to direct the child's actions are consistent with the phase of complexity at which the Ecolab is currently operating.

In addition to providing the child with the facilities to build, activate and observe a simulated ecological community, the Ecolab also provides the child with small activities of different types. The activities are designed to structure the child's interactions with the system. They provide a goal towards which the child's actions can be directed and vary in the complexity of the relationships which the child is required to investigate. There are, for example, exploration activities that challenge the child to examine the relationships that exist between the organisms she has selected. She might be asked to see how many links she can add to a food web diagram for example. In addition to these variations, the Ecolab environment built by the child can be viewed in different ways, each of which emphasises a particular aspect of the relationships that currently exist within the Ecolab. All views have the common feature of a menu bar across the top of the screen (Fig. 1).

Views common to both generations of the software are:

- *World view* shows a picture of the organisms that are currently members of the Ecolab environment.
- *Web view* provides a diagrammatic representation of the organisms and the links that exist between them in a manner similar to the food web diagrams used in text books.
- *Energy view* illustrates each of the live organisms in terms of their current level of energy in a block graph.
- Within each of these views most of the screen objects will provide the child with information when clicked on with the mouse. For example, clicking on an organism in World view will yield the organism's name, what it eats and what eats it. Which view a child uses is largely, though not completely, under her control.

The Ecolab can scaffold the child in several ways. Firstly, it can offer graded help specific to the particular situation. The higher the level of help the greater the control taken by the system and the less scope there is for the child to fail (Wood et al. 1978). In addition to offering the child specific hints to ensure the activity is completed successfully, the difficulty level of the activity itself can be adjusted. In the second generation Ecolab II a metacognitive level of scaffolding has been added to engender planning and help seeking skill acquisition. Both Ecolab I and Ecolab II are systems designed for use by a single learner and the collaboration that takes place is between the system itself and that learner. More information about the Ecolab can be found in (Luckin & du Boulay, 1999; Luckin & Hammerton, 2002).

2.2. The Galapagos CD-ROM

The second software example we will consider is the *Galapagos* CD-ROM, built as a research tool to help us explore the implications of narrative for the structure of group collaborations with multimedia. The CD-ROM described Darwin's visit to the Galapagos islands and his resultant

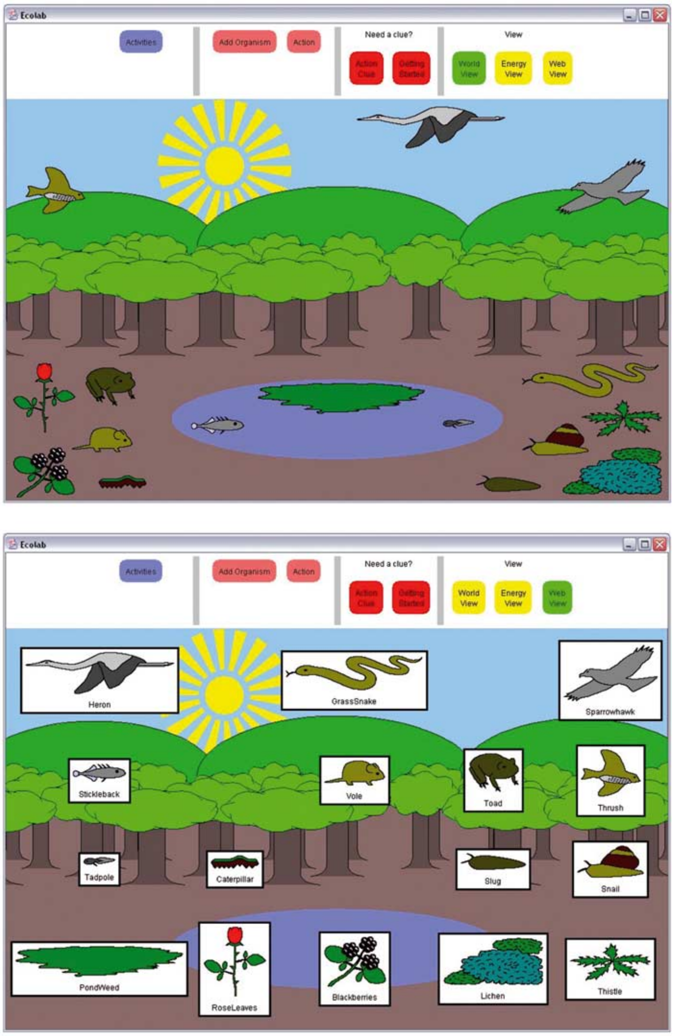


Fig. 1. The Ecolab II interface in World and Web view.

theory of evolution. It was composed of eight sections of content material, each of which deals with a particular aspect of Darwin's visit. Learners were set the task of using the resources provided on the CD-ROM to construct an explanation of the variations in the wildlife on the islands using an on-line Notepad. The full set of sections is as follows; the section numbers are used for convenience here to refer to sections, 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

In addition to these sections of content material, learners had access to the following information via a tool bar at the bottom of the screen, see Fig. 2 which illustrates a screen shot of the Guided Discovery Learning version of Galapagos with a section of content called "Trade Winds" in use.

- A reminder about the task they had been asked to complete at the outset of their interactions with Galapagos.
- An editable Notepad in which they could take notes and write their answer.
- A Model Answer, which was a sample of an acceptable answer to the task. This answer could only be accessed when they had written 50 words in the Notepad.
- A script window that contained the transcript for all audio material.

For more detail about these features see (Luckin, Taylor et al., 1998)

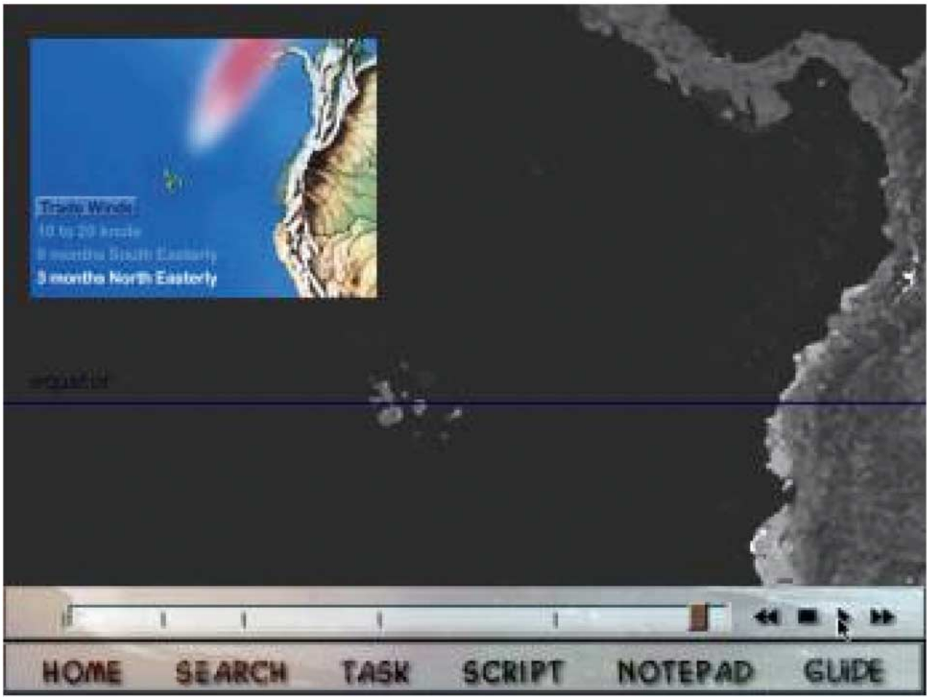


Fig. 2. *Galapagos* Trade Winds.

2.3. Digital toy technology

The third and final technology we will explore is that of digital toys. There are an increasing number of digital toys available on the commercial market and many of them make claims about their educational affordances. It seems reasonable to consider them as possible tools with which to engender collaborative learning. These toys provide a new form of interface: one which is not televisual or text-based, does not use a desktop metaphor and does not rely on a keyboard or mouse input. Instead, they exhibit a range of interface modalities: they are anthropomorphic (Don, 1992), emotional (Strommen and Alexander, 1999), sympathetic (Johnson, 1999), manipulative (Resnick, 1998) and haptic (Fogg, 1999). The toys are qualitatively different from animated pedagogical agents because they are not screen-based, virtual objects but things that can be squeezed and cuddled. There is an expanding market for increasingly communicative digital toys.

These toys all raise many questions about educational value and benefits as well as broader issues. From the CSCL perspective we can ask for example: how do children interact with and around the toy? How can we make the best use of these toys to promote CSCL? There are also toys that, in addition to interacting with children in their own right, can be linked to a standard desktop computer and used in conjunction with associated software. We can then ask for example: Do the toys and accompanying software promote collaboration with, through or around the technology? In this paper, we look at how one might document and analyse young children's interactions with these toys.

3. The evolution of a multi-dimensional documentation technique

3.1. One dimensional collaboration: documenting a single user's collaboration with a software learning partner

The method for documenting collaborative interactions described in this section was first developed for the evaluation of the Ecolab I software and was subsequently used with Ecolab II. In both generations of the Ecolab the software enabled the computer to play the role of a collaborative partner for the child learner. The documentation of the collaborations between child and computer took the shape of an annotated user log that was represented graphically. The learning gains made by children using Ecolab were also evaluated using a pre- and post-test methodology. This work is reported elsewhere (Luckin & du Boulay, 1999; Luckin & Hammerton, 2002) and is not the main focus of the current paper. It is the manner in which we can record and analyse the character of the interactions and collaborations between each child and the system that we focus upon here. Through the annotated logs of children's use of the Ecolab we wanted to investigate how the software had supported and encouraged various types of interaction and collaboration in order to inform the design of future systems. An exploratory evaluation of the Ecolab I software offered the first opportunity to test the documentation technique that forms the focus of this paper. This evaluation was conducted with a class of children aged 10 and 11 years to investigate the extent to which the software would be able to adjust to each learner and the ways in which the interactions and collaborations between learners and software varied. Prior to using the software each child completed a written and a verbal pre-test, the latter of which was in the form of a structured interview recorded on audio tape. Each child used the Ecolab software as an individual for a total of 60 min over two sessions. In addition, a 20 min initial session with a smaller 'demo' version ensured that all children were comfortable with the mouse skills required and the interface. After the system intervention subjects were given a written and verbal test, identical to the pre-test, and a short additional extension interview. Of the 30 children who started the study only 26 completed all sessions between, and including, pre and post-test. The four who did not complete these sessions had either left the school or been absent during the evaluation period. For each child who used the software a summary record of their interactions was produced from the detailed logs maintained during their sessions of system use and this was used to build up a picture of the types of interactions each child experienced with the system [for full information see (Luckin, 1998)].

Cognitive or learning styles have been a subject of active interest in recent years (Goodyear, 1991; Groat & Musson, 1995; Pask, 1976; Riding & Read, 1996), for a brief review see (Valley, 1997). The influence that a learner's style can have upon the way they interact with technology has also been recognised (Riding & Rayner, 1995). Within this literature there are examples of classification systems that differentiate learners according to their learning preferences; for example, as serialists or holists. The analysis of the annotated interaction summaries of children's experiences with the Ecolab software took a fresh perspective on classification using only the styles of interaction or *Profiles* which could be found in the records of each child's system use and emphasized our interest in the nature of *Interaction* and *Collaboration*. Characteristics were identified and children categorised through:

- *Interaction Profiles* according to the character of their interactions with the Ecolab.
- *Collaboration Profiles* according to the nature of the collaborative support provided by the system for the child.

For the purposes of this paper we will narrow down our focus further and concentrate upon the Collaboration profiles and their documentation in the annotated logs. Fig. 3 illustrates one child's annotated log for one session with the Ecolab I software. Each line in the chart represents a type of event. For example, line 1 represents adding organisms to the Ecolab world. Each block on the line represents a single event. The letters and numbers which annotate the blocks specify further details. For example the first block on line 4 in the example is annotated with "rl", "A" and "d2″. The "rl" indicates that the activity was of the Rule Definition type, the "A" indicates that it was at the "energy-transfer" area of the curriculum and the "d2" indicates the level of difficulty used within this activity template. Line 7, labelled "errors", indicates the times when the system had to help the child to complete an action successfully. The annotations on the two blocks on this line in Fig. 3 indicate that the action the child was trying to complete was an "eat" action and that the help offered was initially at level 4 (h4) and then raised to level 5 (h5). Table 1 presents an extract from the coding scheme used for the summary records produced.

For the purposes of constructing collaborative profiles from these annotated logs two pieces of information were most important. First, the level of difficulty at which the child was tackling an activity as represented by the d*n* annotations on the blocks on line 4 of the log chart. Second, the level of help used as indicated by the h*n* annotations to the blocks on line 7 of the log charts. From this information the two characteristics that were found to be the most useful for

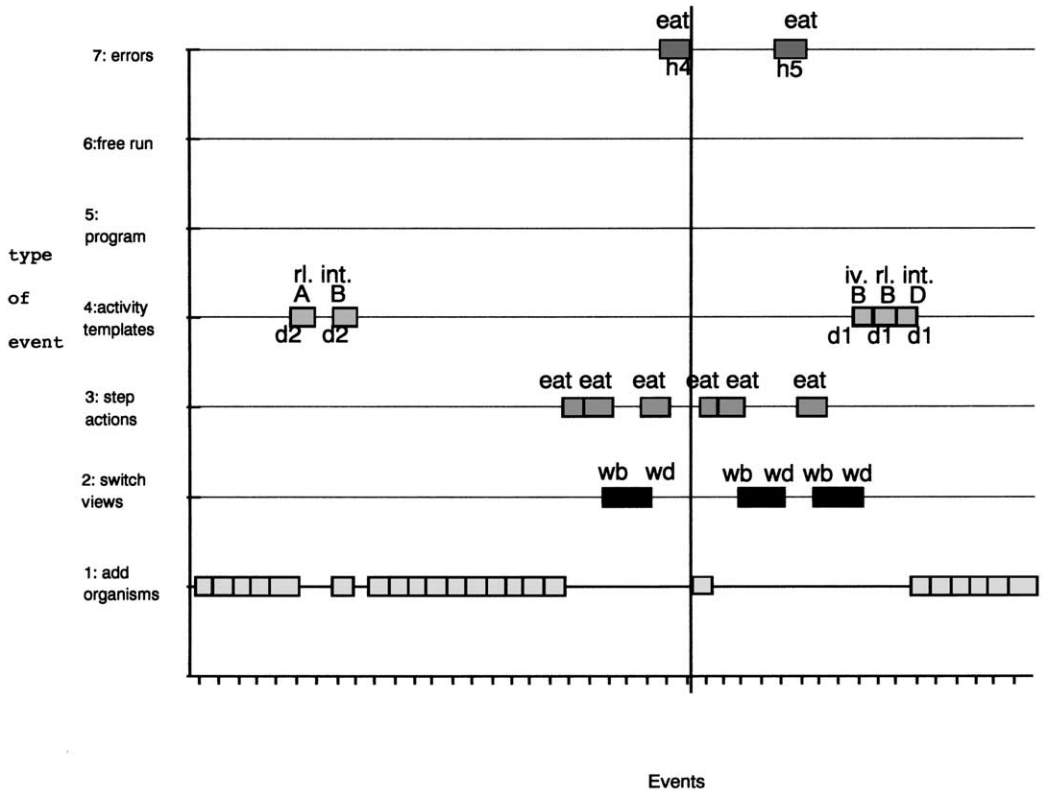


Fig. 3. Annotated Log for a child using the Ecolab software.

Table 1
An extract from the coding scheme used for the summary records produced

Category of event	Sub-category of event	Code
Switch view	World	wd
	Web	wb
	Energy	e
Action	Move	mv
	Eat	eat
	Be eaten	be
Activities	Introduction	int
	Investigation	iv
	Integration	ig
	Rule-Definition	rl
	Upper case letters A—L indicate node of the curriculum	
	Numbers d1—d3 indicate differentiation level of activity	
Errors	Letter codes correspond to event during which error occurred	
	Numbers h1—h5 indicate level of help given.	

differentiating collaborative style within the interactions were extracted. These characteristics were: the *Amount* of support and the *Depth* of support provided by the system for the child.

Amount of support: the average amount of activity differentiation (i.e., the degree to which the activity is presented in a simpler form) and the average number of help instances for the experimental group was calculated. An above average amount of either activity differentiation or instances of help was the criteria necessary for a child to be considered as using 'Lots' of collaborative support.

Depth of support: this characteristic was based upon the level of help and level of differentiation used. Once again the average levels used within the experimental group were calculated. Help or differentiation above the average level resulted in a child being considered as using a 'Deep' or higher level support.

These collaboration characteristics were used to group the children into one of four Collaboration Profile groups. The first group was the largest and was further divided in accordance with the type of support which was most prevalent. The distribution of children into these groups is illustrated in Table 2.

3.1.1. An example of a child's collaboration profile

Jason's use of the available support was typical of the *Lots and Deep* profile group and of a user of above average amounts of both help and activity differentiation. He used level 4 help early in his first session of system use to achieve success in making organisms eat each other. His initial activities were completed with maximum differentiation of level 3. This was gradually reduced and then increased again. During his first session of system use he completed a range of activities for three nodes in the first phase of the curriculum. All instances of successful help were at level 4 or level 5. Fewer activities were completed during his second session. However, these activities were at a lower level of differentiation and there were fewer instances of help. This Collaboration Profile group was the largest and was subdivided to account for the type of support used. Jason was a member of the subgroup which used above average amounts and levels of both activity differentiation and help.

3.1.2. Benefits gained from the documentation of collaborations with the Ecolab

The results from our analysis of the Ecolab I software using the documentation technique described above highlighted the benefits that accrue when learners are challenged and intellectually

Table 2
Distribution of children within Collaboration Profile groups

Profile Description	% of children in Profile	Profile sub-group Description	% of children in Profile sub-group
Lots and Deep (LD)	53%	Differentiation and Help	19%
		Differentiation	19%
		Help	15%
Lots and Shallow (LND)	12%		
Little and Deep (NLD)	16%		
Little and Shallow (NLND)	19%		

extended. It also illustrated the difficulty that such young learners have in achieving this intellectual extension without explicit direction from the system. The findings of this evaluation proved to be consistent with the findings of Wood (Wood & Wood, 1999) and indicated that less able and less knowledgeable learners were especially ineffective at selecting appropriately challenging tasks and seeking appropriate qualities and quantities of support and guidance (Luckin & du Boulay, 1999; Wood & Wood 1999). The documentation and analysis of children's interactions and collaboration with the Ecolab I software enabled us to identify the areas for development upon which we wished to focus in our production of the Ecolab II software. This second generation of the Ecolab explored how software scaffolding at the metacognitive level can be provided so that learners can become more effective at reflecting on their own needs, at seeking appropriate challenges and appropriate support. Our goal was the production of a system which could assist a learner to take more control for her own extension, which modelled a learner's developing collaborative skills as well as her developing understanding of the curriculum [for more information on Ecolab II see (Luckin & Hammerton, 2002)]

3.2. Two dimensional collaboration: documenting groups collaborating around and with a multimedia CD-ROM

The documentation technique used with the Ecolab software charted a single dimension for collaborative activity: a user's collaborations with a piece of software. The next step in our development of the documentation required us to chart a second dimension of collaborative activity. The software in question was a multimedia CD-ROM designed for use by groups of older learners as they co-constructed a textual narrative about their understanding of Darwin's theory of evolution (Luckin et al., 1998). In this second learning situation, interactions were between learners around the computer as well as between the computer software and the learners. This was a more complicated situation and the original one-dimensional chart used for interactions between a single learner and software had to be expanded into a two-dimensional chart that could represent the interactions in-between learners as well as those between learners and the CD-ROM. On this second occasion interactions were captured via two video sources, one of the computer screen and the other of the learners. The video data was then transcribed and coded. The categories used for the dialogue between learners as they used the CD-ROM were carefully selected in order to enable us to differentiate the times when learners were focusing on procedural or operational issues from the times when they were trying to construct an understanding of the underlying concepts about evolution [see (Luckin et al. 1998; Luckin et al. 2001) for more detail about the methodology]. The resultant graphical representation was called the Chronologically Ordered Dialogue and Features Used (CORDFU) chart and was the development of the original annotated user log from the Ecolab evaluation. It is illustrated in Fig. 4.

In Fig. 4, the upper part of the vertical axis (above the bold horizontal line) records the different features of the 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. Only the names of the features and categories present in the example have been included in Fig. 4 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 measure-

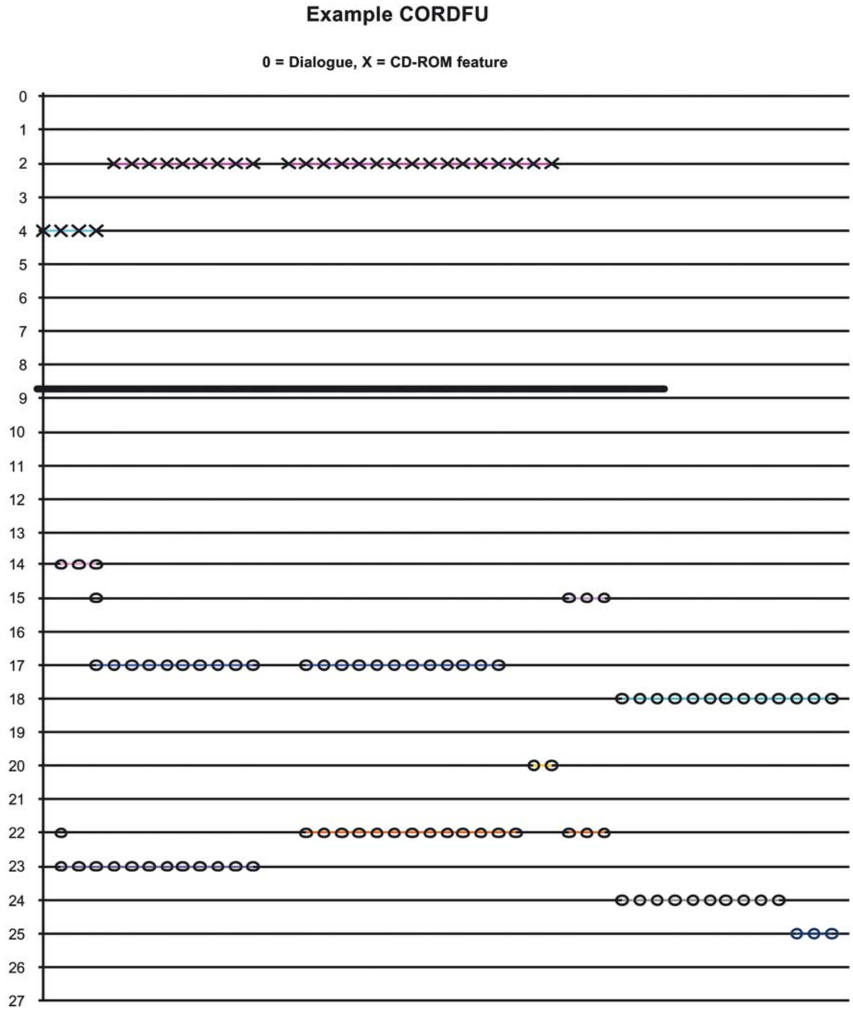


Fig. 4. A section from a CORDFU chart.

ment is a text unit that 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. An 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 Fig. 4 we can see that the group of learners it represents used the notepad in conjunction with the introductory section whilst discussing their reactions to the multimedia and the practicalities of constructing an answer to the set task

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

3.2.1. Example: a group of learners using Galapagos and the associated CORDFU representation

Four groups of three students, aged between 15 and 21 years, used *Galapagos*. The 36 students were based in two different institutions 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 min. The goal of our analysis was to understand: 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 an extract from the results of this study to illustrate how the CORDFU documentation enabled us to explore how learners used the various system features. To illustrate this we present 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 of the way in which groups using this system version used the CD-ROM features available to them.

Fig. 5 presents a section of the CORDFU for one group of learners. In this section the Guide tool is being used to navigate between two sections of content material: "Island Formation" and "Trade Winds". Most talk is content related, both when the information about islands and trade winds is on screen as well as when these are used in conjunction with the on-line notepad. They talk about the importance of the Galapagos being an island and how this relates to the task.

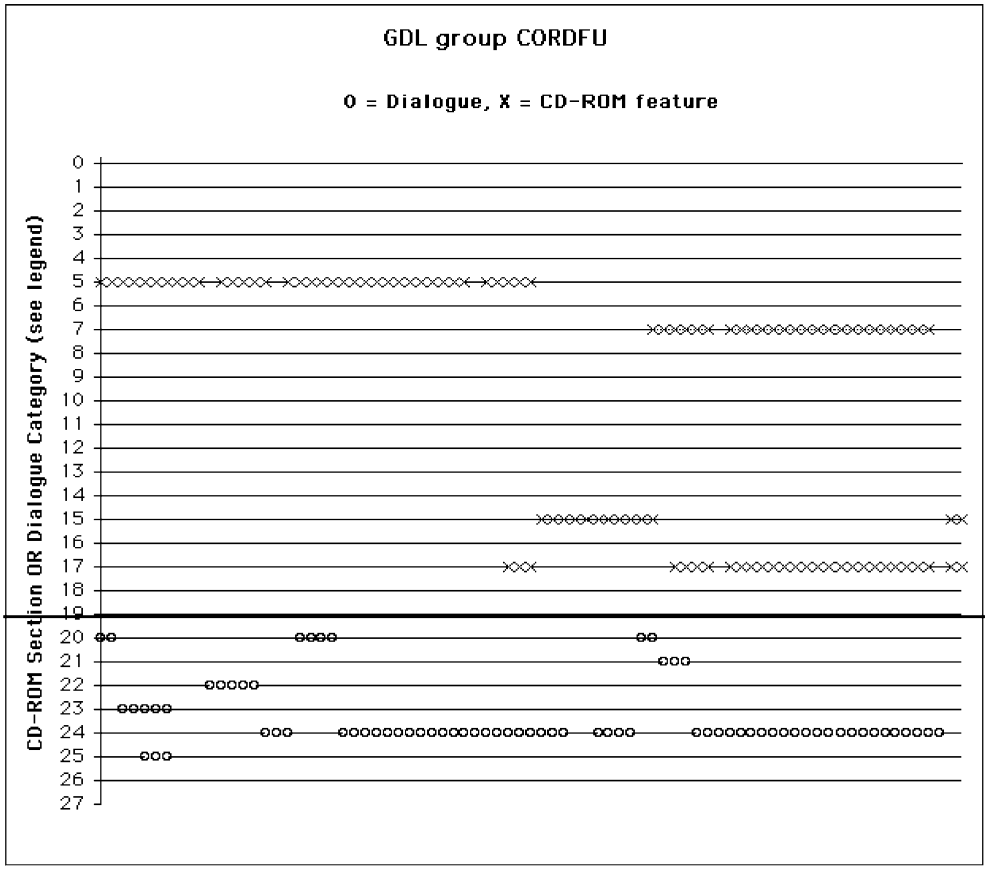
3.2.2. Benefits gained from the documentation of collaborations with the Galapagos

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 one example of users interacting with the *Galapagos* CD-ROM. The use of the CORDFU documentation technique allowed us to elicit a great deal about how learners used the different software features within the CD-ROM. For example, we were able to ascertain that the software guide helped users make connections and build links between the task they had been set and the individual elements of content, for example. One of the outputs from the *Galapagos* analysis was a set of guidelines for multimedia designers that included:

3.2.3. Guideline

Use narrative guidance features to guide the learners to the internal structure and content of the given narrative, its supporting arguments and evidence. To achieve this include:

- A 'Goal' to provide a coherent framework for the given narrative;
- 'Reminders' of the goal, to keep the structure of the narrative in focus
- A 'Guide' to sub-goals or essential components or investigations, to help learners relate their investigations to the structure of the narrative;



CD-ROM Features

5 = Section 3: Island Formation
7 = Section 5: Trade Winds
15 = Guide
17 = Notepad

Dialogue Categories

20 = Non-Task
21 = Task
22 = Content: Sub-goal formation
23 = Content: Reaction to MM
24 = Content: Answer text Construction
25 = Content: Model answer

Fig. 5. A section from a User Group CORDFU chart.

- A 'Model Answer' whose content and structure, once revealed, will provide formative feedback on their own account, which can then guide them towards further investigations.

But the focus of this research was to identify fundamental characteristics of the learning conversation that took place between learners and media, such that we could in theory apply the same findings to all these contexts and expect to generate a more effective learning experience as a result. A vital component in the success of this work was the analysis of the collaborative interactions recorded through the CORDFU documentations technique. The expansion of the original Ecolab methodology to the Galapagos work necessitated the inclusion of an additional dimension to the collaboration to track what happened in between individuals in a group of learners as well as between those learners and software.

3.3. Multi dimensional collaboration: documenting children collaborating with multiple interfaces

The final example and the latest stage in the evolution of our approach to the documentation of collaborative interactions is part of the CACHET research project, which aims to construct an explanatory framework for the interaction and mediation engendered by digital toys. The electronic toys used in this project are freestanding soft toys that can move, speak and respond to a child's touch. They can also be 'linked' to a PC with a special unit that transmits information between the toy and the computer (although no cables are required). In freestanding mode (they are about 30 cm tall) these toys superficially appear like traditional soft toys but they have motors to provide limb and head movement and a ROM chip so they respond to inputs. The toys can gesture, using programmed motion, and speak, using a digitised vocabulary of more than 4000 words, so they can play simple games. Interaction operates through sensors located in parts of the toy's body, each of which controls a different function. Combined with compatible software, this enables further interaction through educational games. The software encourages basic language and number skills and the toy can comment on the child's interaction, provide feedback and give support. The software increases the toy's vocabulary to 10,000 words and the toys can receive radio signals more than 3 meters away from the transmitter at the PC. The child is therefore no longer interacting solely with the computer or solely with the toy, but is also interacting with their toy that, in turn, interacts directly with the computer and mediates the child's actions.

In an initial pilot study 32 children (aged 4 and 5 years) enjoyed interacting with the toys and the software. Although some of the memory and alphabet games featured in the toy repertoire proved beyond most of the younger children' ability it was clear that children were able to demonstrate competence with the interface within a short period of time. However, a number of important individual differences in interaction style began to emerge. On one hand for example, some children tended to use the toy simply as a pretend item—using it much as children would use a teddy bear, making it walk and pretending that it spoke to them, while ignoring the toy's interactive repertoire. On the other hand, some children were very attentive to the vocalised prompts from the toy, and endeavoured to interact with it to the best of their ability. When interacting with the software, the comparison between the radio controlled toy and the on-screen icon proved interesting. The pilot studies, then, confirmed the need to document the different types of interactions that occur between child, toy and computer. Two of the research questions that are driving our current work are:

- To what extent do children understand the toy interface: do they interact with toy's repertoire, or simply use it as a teddy bear that makes noises?
- Where is the interface for communication and collaboration when children interact with the toy and the computer software?

It is to these questions that the remainder of this case study turns. In particular we consider how we have developed the CORDFU charts to document the interactions effectively.

3.3.1. Adapting the CORDFU chart for more than two dimensions of collaboration

Within our empirical work we have concentrated upon capturing data about the process of the interactions that occur with digital toys. We have also collected performance based data on individual participants in order to enrich our understanding of the profiles of the children that engage in particular sorts of interactions either with the technology or with other children around the technology. The study was divided into three stages:

- *Stage 1*: Children (individually and in pairs) were introduced to the toys and allowed to play with them for a period of up to 15 min. During this time a functionality checklist was used to ensure that all the children participate in a common core set of interaction types.
- *Stage 2*: Children were divided into two groups. Children in Group A were introduced to the software without the toy, the character would instead appear as an animated icon on screen. Children in Group B used the software with the toy activated as an interaction partner. As in Stage 1, the functionality checklist was used to ensure that all the children participated in a common core set of interaction types.
- *Stage 3*: Semi-structured interview. Children's conception of the toy was assessed by a scripted interview. All children also completed the WPPSII (Weschler Primary and Pre-school Intelligence Inventory) to assess their verbal and non-verbal ability.

Video was once again our primary data source with all of the sessions in which the children interact with either the toy and/or the toy software being recorded on digital videotape, as were the post-interaction interviews. The screen image when the software was in use was also captured on standard analogue videotape through the use of a scan converter and VCR. The original CORDFU representation of Fig. 4 allowed us to integrate information from two dimensions: the first was the path navigated through the CD-ROM by each group of users, the second was the category of talk that occurred between the learners when a particular CD-ROM feature was in use. The new version of this representation that we have created and which will be presented for discussion here required the addition of two further dimensions

Dimension 1 Children's use of software features and any dialogue between on screen characters within the software

Dimension 2 Dialogue between children or between researcher and children

Dimension 3 Children's use of toy features and 'dialogue' with the toy (sensor squeezes, cuddling etc.)

Dimension 4 Interactions between toy and software.

We do still need a Chronologically Ordered Record of Dialogue & Features Used (CORDFU). But in this instance we need to differentiate the locus of the Features Used to specify at which interface they occur (toy or software), we also need to add the interactions that occur between these two: the toy and the software. The new charts provide a Chronologically ordered record of Features in use, Focus of interactivity and Dialogue (CFFD). Fig. 6 illustrates a small section of a CFFD chart. Each horizontal line shows one of the categories of speech and action that can be performed by the interactors in this session: the researcher, the children, the toy and the software. These actions make up the interactions along the four dimensions identified above. The links

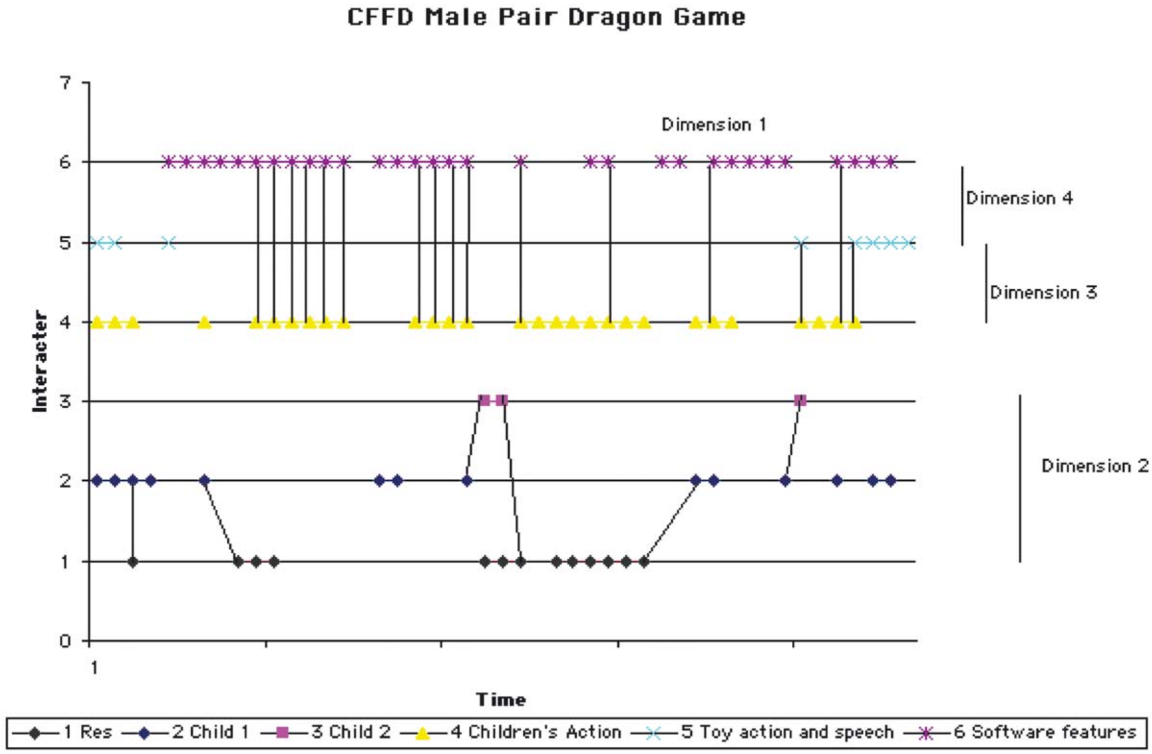


Fig. 6. A section from a CFFD chart for two children using the toy and software.

between the horizontal lines indicate the interactions between the participants along these dimensions.

As yet it is early days for the CACHET project data analysis and the documentation techniques being developed are very much work in progress. However, our initial results are positive and lend weight to the suggestion that new technologies do not necessarily require new forms of documentation. For example, we are noting that there is increased social interaction between children when the toy is present as in the example used in Fig. 6, as compared to when the toy is not present and the software alone is offering the functionality. In stage 2 of our study children were divided into two groups: children in Group A are introduced to the software without the toy, the toy character appears as an animated icon on screen instead; children in Group B use the software with the toy activated as an interaction partner. The increased social activity is indicated by greater activity along dimension 2 in the CFFD charts of children whose interactions include the toy as well as the software.

4. Conclusions

In this paper we have discussed the challenges posed to the CSCL researcher by the changing use of technologies for collaboration. A technique for the documentation of collaboration, used originally in a traditional and single learner context has been presented and explained. Its potential for application in further CSCL contexts involving groups and novel technology has been discussed. It is clear that tried and tested techniques can be adapted and re-used, provided the foci of interactivity are clearly specified and the appropriate data sources identified. The technique discussed is one approach and is offered, along with suggested adaptations to motivate discussion and further work. Of course, it is both reasonable and pertinent to consider the following question: if it is the collaborative interactions between learners or between learners and technology that we aim to document and analyse, why should the nature of the technology make any difference? It is, after all, merely the channel for communication and not the focus of attention. This question is one that can only really be addressed by actually trying to devise a means of documentation and it is to this that our work has paid attention.

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