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A Structured View of Dialogue Context as a Basis for Addressing the Interactive Re-Use of Educational Dialogues

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Abstract

Learning by observing spontaneous conversations between other learners is an educational task which has been proved to be effective (Cox *et al.* 1998). A challenging goal is to accomplish such a task through a tutoring system and to show how it can be usefully supported by formal accounts of educational dialogue. In particular, there is a need for characterising the indeterminacy of the problem and addressing the question of the nature of *context* in such applications. This paper presents a representation of context which integrates pre-existing methods and models. The perspective taken is motivated by empirical data. It is aimed at identifying informational needs of overhearers and at determining design principles which can drive the implementation of hypermedia educational environments.

Introduction

Tutorial dialogues from one context can be usefully reused as representations to be accessed interactively by other learners. Our study aims at providing a clearer basis for approaching such re-use, and its potential application in intelligent tutoring systems. In particular, we look at how dialogues produced by pairs of learners can be re-used (through video presentation) as a resource by other learners. We refer to these other learners as overhearers.

In the course of such dialogues, by their nature, local variations in focus and goals occur, and consequently the context which these dialogues provide for the overhearers also changes. Such an application is characterised by independence of teaching and learning from time and place. A dialogue episode installed in one place may be accessed by a number of users in different contexts. Is there a most appropriate representation of dialogue context such an application should rely on? Is it possible to provide at least a partial description relying upon objective linguistic features of dialogue? The task requires an investigation on the nature of context. In particular, we question how a representation of it can provide a basis for assessing the effectiveness of the task by relying on overhearers' contributions.

Vicarious learning from others' dialogues

The expository function of dialogically testing ideas has been widely used in the past. There is a literary genre that uses dialogue as a form of exposition, as in Socrates' and Plato's dialogues, and as Hume or Berkeley do for pedagogical purposes. In the present work the idea is slightly different, since spontaneous conversations are to be used. The observational learning from others dialogues has raised interest in recent research. Cox *et al.* (1998) present a comparison between the educational utility of re-used discourse (expository tutorial discourse by a lecturer) with that of re-used dialogue (dialogue between a student and a tutor). The comparison was aimed at examining whether students can benefit from dialogue as observers, not just as participants. The results indicated that re-usable dialogue is a useful resource for the vicarious learner.

A specific interest is in the question of whether and how dialogue can be usefully re-used for *vicarious learning*. Vicarious learning happens when people benefit from just watching another person's learning experience relating it to their own problems. The starting assumption is that much real learning occurs through observation of other learners engaged in active dialogues. In particular, dialogue episodes between students in the process of understanding some issue can be recorded, selected, segmented and re-used as tertiary courseware.

Tertiary courseware (McKendree *et al.* 1998) is a new conception of courseware of which there are few current examples. It involves the 're-use' of the products of the learning experiences of other students. McKendree *et al.* (*op. cit.*) have been looking broadly at issues concerning the development of a multimedia database system to promote and enhance the role of dialogue in learning.

Accordingly, the dialogue episodes we have selected from our recordings are interesting, not because they display clear explanations, but rather because they allow a learner to access past experiences of other learners. They embed motifs, preconceptions, and essential questions, which could be recognised by an observer as relevant to her own experience.

The dialogue episodes

The initial motivation for our approach is the data we obtained from videorecording learners' conversations. The conversations involve pairs of students struggling to understand the meaning of a statement about the mechanics of the physical system represented in Figure 1.

Selected dialogue episodes were segmented and framed in order to make them accessible by other learners. Selection of the episodes aimed at isolating bits where essential questions regarding the knowledge domain are made explicit and addressed. Inevitably, the dialogue episodes have to be selected by a teacher who has some educational goals in mind. As argued in the following, who chooses, frames and annotates each episode is driven by subjective criteria concerning selection, perspective and evaluation. Also, the most relevant issues in the representation might well be a only very small subset of the whole. As we argue, these facts contribute to the complexity of the problem of analysing dialogue re-use.

Example In the following example one of the two students takes acceleration to be proportional to velocity, which is a common misunderstanding at this stage of learning. Deirdre's misunderstanding provides motivation for engaging her and the interlocutor in the inquiry on the nature of acceleration. A teacher might want to show the following episode to other students (overhearers) because it embodies a relevant issue: the acceleration of both moving bodies is constant. Other teaching goals could include: to situate or motivate an inquiry on the nature of acceleration; to prompt reflection by showing the derivation process through which two students resolve a common misunderstanding.

1 **Eimear**: The one falling straight will have a much bigger acceleration than the other one.

2 **Deirdre**: Yeah. (Pause) But then, (Pause) by the time it gets to the end of the slope, the acceleration is going to be like... you know what I mean?

3 **Eimear**: But it will never be as much as the acceleration of the one free falling.

4 **Deirdre**: Yes, that's true. (Pause) But... ?

5 **Eimear**: 'Cause I mean, if something is going down the slope there's friction and that's the end of it, and that is gonna slow it down. Whereas, something falling straight, (...) than that's gonna fall faster than that with a bit of friction, even if it is a perfectly clean, straight (slope).

6 **Deirdre**: I don't know,... is that true?

7 **Eimear**: Mhmh. (Yes.)

8 **Deirdre**: Even if it is just from here, you know? 'Cause, like... you only have one meter to get to the ground... whereas the other one going down the Mount Everest has already picked up... you know?... a huge huuge huuuge speed.

9 **Eimear**: But acceleration is irrespective of the distance. (Pause) You know?

10 **Deirdre**: Right, OK.

11 **Eimear**: If something falls like... a meter or it falls a thousand meters... it's still how much... (it's actually a matter of force.)

12 **Deirdre**: What's acceleration like?

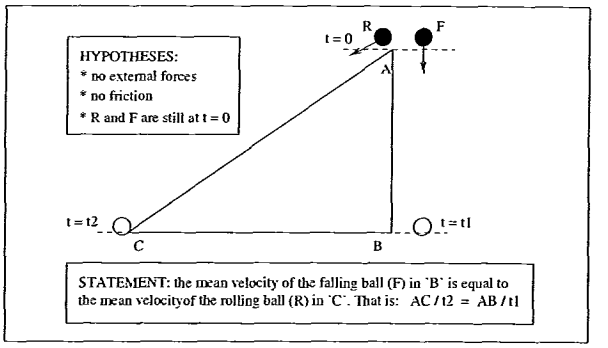


Figure 1: The domain problem addressed in the dialogues.

On the notion of *context*

The application we are after presents some difficulties which concern, on the one hand, features of videorecorded dialogue episodes as a particular representation modality. On the other hand, there are difficulties with engaging such representations in activities and with agents whose intents and capabilities differ from those characterising their original context of production.

On the one hand, such episodes cannot be treated as parts of multimodal presentations in the same way as textual explanations or diagrams. The way we interpret and use dialogue episodes is inherently different. They lack essential features of such other modalities of representation. In particular, they lack productivity and conventionality (Currie 1995). Furthermore, the notion of context on which dialogue participants rely is inherently richer than that which is needed for interpreting a written explanation.

On the other hand, since understanding in dialogue is usually based on a collaborative effort, there is a problem with the overhearer not being able to intervene *in the dialogue* for clarification. The context of her observation can reasonably be different from the context in which the dialogue has been generated. Also, we should question whether, and to what extent, context-interpretation while participating the dialogue works just as when observing it.

As a consequence of these difficulties, every attempt to address the re-use of the dialogues for educational purposes must address the question of what is an appropriate representation of *context*. That is to draw a boundary between *context* and the phenomenon that it is context to. In addressing this problem, one should be aware of how (Duranti & Goodwin 1992) the solution changes according to the perspective taken. What a participant treats as a relevant context is shaped by the specific activities being performed at that moment.

We can start by observing that overhearers involved in our study treat the dialogue episodes' stream of activity in a selective way. The question of what in the representation they treat as "focal" and what as "context" can then be addressed by relying on the comments they produce while observing it. In such an attempt we will rely on the assumption that a single representation of dialogue context can account for both

the dialogue episode performance and for its observation.

An overhearers' perception of context depends on subjective criteria. Her description might not suit the interpretation of another who observes the same episode from a different perspective, in a different situation. Is it possible to provide at least a partial description relying upon objective linguistic features of dialogue? To this end, we apply the model for representing dialogue context which Ginzburg (1996) developed from a notion of *accepting* dialogue contributions (Clark & Schaefer 1989) which is related to the concept of *common ground*.

From a cognitive perspective, Clark and Schaefer (*op. cit.*) have accounted for how the process by which shared understanding is jointly constructed can be represented by contextual attributes. Clark and Schaefer point to how speakers adhere to a criterion of grounding:

> The contributor and the partners mutually believe that the partners have understood what the contributor meant to a criterion sufficient for current purposes. (*op. cit.*, p. 262)

Speakers are meant to do this by generating "contributions". Our study relies on a representation of contextual change that develops from Clark and Schaefer's, but contrasts with two relevant aspects of it (Ginzburg 1998):

- *Grounding Precedes Presupposition*: before an utterance's content enters into the common ground, the other dialogue participant must explicitly acknowledge it as understood.
- *Equal Access to Context*: as a conversation proceeds, a common ground emerges. After each turn, a dialogue participant takes over from the common ground point at which the other one spoke.

Ginzburg's model contrasts the two points. Through its perspective, common ground is not necessarily equally accessible by the participants and there is a much more "fine-grained" definition of what may be *context-dependent* information.

Such an account suits our case particularly. Our study shows that these issues are critical to the application of reusing dialogues for vicarious learning.

Ginzburg's model

Ginzburg (1996) argues for the need of a structured view of context. An important observation is that a relevant feature of dialogue is its *locality*. Locality can partly be accounted for by Dialogue Games. Moves often come in move/counter-move pairs, as dialogue games rule out. However, not everything about the locality of dialogue is explained by the adjacency of moves. In fact, not all moves react to immediately preceding moves, and locality also influences how people select topics for both performing and interpreting dialogue. The model developed by Ginzburg involves keeping track of questions that get introduced into the context, or as he puts it, that arise, as long as they remain under discussion. One intention is to keep track of the *discursive potential*: a restricted set of topics the participants usually can select for discussion.

The model achieves this by defining what semantic properties questions are required to have in order to specify the discursive potential. Other attributes are introduced which constitute each participant's contextual repository:

- FACTS: the set of currently accepted facts.
- LATEST-MOVE: represents the syntax and semantics of the latest-move made. It is permissible to make whatever moves are available as reactions to the latest-move.
- QUD (Questions Under Discussion): a partially ordered repository that specifies the currently discussable questions. The maximal element of QUD corresponds to the current topic of discussion. If q is maximal in QUD, it is permissible to provide information ABOUT q or a question q1 on which q DEPENDS. The assumption that QUD needs to be an ordered set is motivated by the fact that more than a question can be under discussion simultaneously without conversational chaos ensuing.

Other definitions of this model that we use are reported below (for a more thorough account, see (Ginzburg 1993), (Ginzburg 1996)). The semantic framework utilised for defining the DECIDES, ABOUT and DEPENDS-ON relations mentioned below is *situation theory* (Barwise & Etchemendy 1990).

Definition Given a question q = (s?σ), a *q-specific utterance* is one that either: (a) conveys information ABOUT q. Or (b) conveys a question q_1 such that q DEPENDS-ON q_1.

Updating the QUD set The basic principle for removing a question from QUD is the following: if q is currently maximal in QUD, accepting information φ that either: (a) DECIDES q. Or (b) indicates that no information ABOUT q can be provided, removes q from QUD and licenses adding φ to FACTS.

Exchanges, topic spaces, episodes

The choice of the verbal entities from which we develop our representation of dialogue context must be framed explicitly in one appropriate *structure* of transactions. In particular, it should be made clear how the boundaries and the scope of what constitutes each *exchange* are identified.

In order to represent the dialogue structure along these aspects, we apply the DISCOUNT coding scheme (Pilkington 1999). DISCOUNT relies on utterance function, game structure, and higher level transaction structure. It allows structural boundaries to be traced and annotated according to predefined categories.

The scheme has been developed as a qualitative adjunct to experimental design to help describe and evaluate educational dialogue. A major question is to what extent the dialogue's form and content is instrumental to learning activities.

In identifying the nature of *exchanges* through DISCOUNT, a purpose or intention is identified in relation to what is being transacted and to holds the initiative during

particular phases in the dialogue. In this scheme, the meaning of *exchange* as well as the ontology used in defining its nature is the same as that of (Sinclair & Coulthard 1975).

By marking a *transaction* we aim at identifying the achieving of some goal through dialogue by the accomplishment of exchanges. By using this framework we aim to describe the sense of coherence within and between exchanges. Hence, our choices in annotating the transcripts will seek coherent sequences of dialogue on a common topic. At this level, the coherence of the description of form and function in relation to natural language will be sought by finding a suitable match between move and predicate (for a thorough description and for a methodology, see Pilkington 1999).

The perspective of analysis: a synthetic picture including observers' utterances

Speech events between the dialogue participants in the dialogue are at the same time events to be interpreted by the overhearer. Hence, the context which situates the object of our study should include both performance and reception. As it is well known through studies on theatre, the two major dimensions along which knowledge is distributed in such representations can be identified in a lateral dimension (dialogue participant - dialogue participant) and a projective dimension (stage - observer) ((Herman 1995), p. 29), see Figure 2.

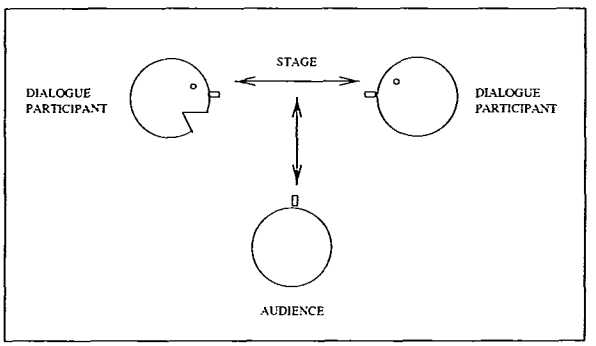


Figure 2: Both lateral and projective dimensions should be considered for assessing communicative functions.

The analysis in this study restricts such a picture to a view in which the lateral and projective dimensions are explored through the relationship between the observers' utterance (providing the dimension P, the projective dimension, in Figure 3) and the contextual attributes of the representations, such as the overall exchange structure, the QUD maximal elements and the "commonly accepted FACTS" (providing the dimension L, the lateral dimension). Dimension P is based on the relationships of q-specific utterance and decidedness (Ginzburg 1996).

Taking this perspective and matching overhearers' utterances against the representation of dialogue context permits the consideration of at least two types of issues: the assessment of the representation's effectiveness, and a characterisation of users' informational needs.

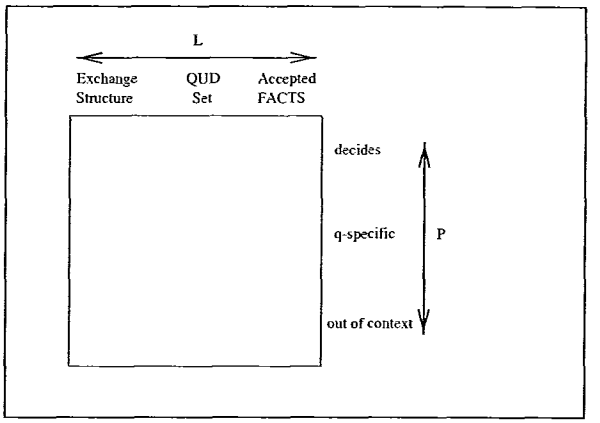


Figure 3: The lateral and projective dimensions can be related to the exchange structure and QUD.

Research questions

The approach permits the investigation of what kinds of observer's reactions might usefully be studied, and raises specific questions concerning the evaluation of the effectiveness of the representation and the informational needs of the overhearers. In particular, the following issues are addressed:

- Does the representation of discursive potential have any relationship to what an overhearer actually perceives?
- What relationships can be identified among overhearers' utterances and specific attributes of the representation of context?
- What are the major informational needs of an overhearer, in relation to the exchange structure and the questions that are under discussion?

By applying Ginzburg's account our study aims at taking benefit from two aspects which contrast earlier accounts of common ground in dialogue. Namely (Ginzburg 1998):

- What is in the common ground is not equally accessible to all participants at a given point (and relevant information, which is clearly presupposed, is not readily accessible).
- For each utterance there is extremely fine-grained potential for discussion of its content, far more than might be expected on traditional views of what is "context dependent".

The empirical evaluation will emphasise that these are critical issues to the application we are concerned with. We question how instructional design heuristics can be suggested on their basis.

Results and discussion

The results of the empirical investigation include the recordings of learners interacting as they undertook a set of collaborative problems. Other learners observed the dialogue

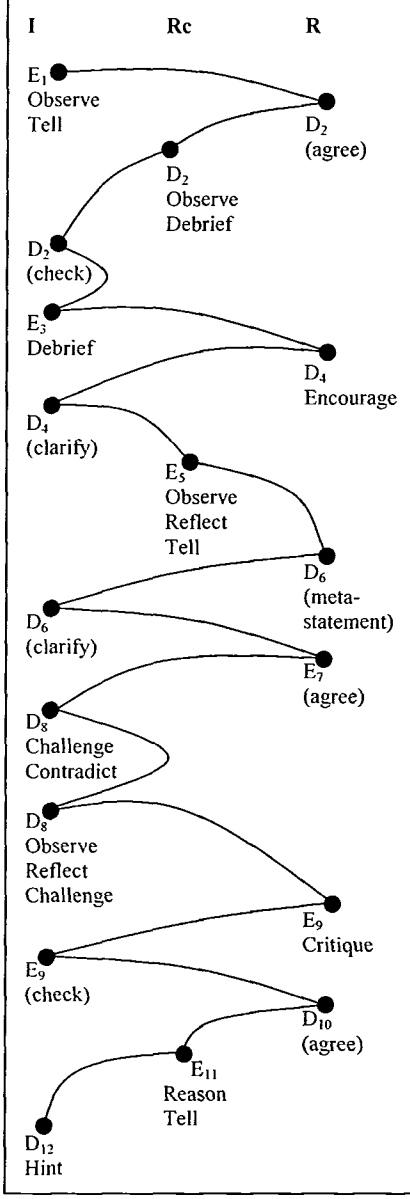
Exchange type and activity type	Maximal elements of the QUD set and "commonly accepted FACTS" (+...+)	Overhearers' utterances
	What is *a*? Which one has bigger *a*? Which one has bigger a? What will *a* be at **B**? + never $a_R > a_F$ + What will *a* be at **B**? Will *F* fall faster? Is friction bearing? What will *a* be at **B**? Does distance matter? + *a* is irrespective of the distance + Does *a* depend on force?	Projected_in: *What does she presume?* Out_of_context: *a is constant.* Projected_out: *I said the same!* Projected_in: *One should think about the force.* In_context: *But friction doesn't matter!* Projected_in: *What does she mean...?* In_context: *But the matter is acceleration!* Projected_out: *I was wrong...* In_context: *But what is the definition for acceleration?*

Figure 4. A joint representation of exchange structure, maximal elements of the QUD set, the "commonly accepted FACTS" attribute (+...+), and observers' utterances of the dialogue segment reported in the introduction. 'I' (initiating turn), 'Rc' (response complement) and 'R' (respond) are exchange structure categories of the coding scheme being used. Each black dot represents one single *utterance*.

Category name	Qualitative definition	Example
Projected_in	Subjective involvement, and can be coded as 'I' exchange type.	"What does she mean?"
Projected_out	Subjective involvement, and can be coded as 'R' exchange type.	"Then I was wrong."
In_context	Decides, or q-specific utterance of a maximal element of the QUD.	"But friction doesn't matter." (when friction is 'in context').
Out_of_context	Not q-specific utterance of a maximal element of the QUD.	"*a* is constant." (when *a* is 'in context'.)

Table 1.

episodes, and were asked to pause the recording whenever they had any questions or comments. A qualitative study of the nature of their subjective involvement in the dialogue episode was carried out, based on their combined utterances.

Figure 4 reports in the first column the annotations done on one of the recorded dialogues, which is the one reported in the Introduction. The third column reports the overhearers' utterances, which were uttered in front of the same dialogue episode. They are categorised accordingly to Table 1, as explained further.

Note that the four overhearers' contributions are not distinguished in Figure 4. The intention is to move away from individual modelling of each overhearer. The overall goal is to provide an abstraction based on structural aspects of the interaction and to relate such abstractions to the workings of the observed dialogues. The distinction between what is said and what is left unsaid by the overhearers is a subject for further study. Alternative methods of evaluation could include interviewing and characterising the overhearer's background.

The results of the empirical investigation can help better describe the medium resources available to the overhearer and their access procedures. The next section explores the consequences of taking our perspective of analysis for the assessment of educational effectiveness. The data show that some resources might not exist for some overhearers' requirements. These could be integrated by the designer of a tutoring system. This would require mapping the identified information needs to the target resources, as discussed below. First, a qualitative description of the empirical data is provided.

Results' indeterminacy

In Figure 4 both the exchange structure and the maximal elements of the QUD set are represented. The third column contains the overhearers' utterances. They appear largely unpredictable and often out of the context of the teaching goals. They emphasise the indeterminacy of the informational context perceived by the overhearers. In particular, the following aspects are highlighted by the data:

- Attention is selective: utterances show how overhearers do not even perceive the same information. Dynamic media can easily overload human information processing. People deal with this by filtering (Faraday & Sutcliffe 1997).
- Differences in learning goals: if an illocutionary force can be associated with overhearers' utterances, several communicative functions can be identified. These can include: suggesting a different conversational thread, translating what one speaker said for helping the other speaker, asking for lacking assumptions to be made explicit.
- Subjective involvement: there is a range of different kinds of subjective involvement overhearers express with their comments.

These dimensions are related to general principles and objectives of multimedia presentation (Faraday & Sutcliffe 1997). The following dimensions are critical: effective perception: the information should be seen and heard; appropriate comprehension: the information should be understood in a manner appropriate to the task; integration and attention: the user picks out important parts of the message and follows the "story" thread across multiple media streams.

The former and the latter phenomena indicate the complex nature of the empirical results. How they be usefully studied? In particular, by questioning what structural aspects of dialogue can be modelled and exploited, we focus on what is specific to educational dialogues. The next two sections explore the consequences of relying on the structured view of dialogue context for evaluating how a dialogue episode is effective to an overhearer and for the guiding of the implementation of educational hypermedia.

Assessment of the representations' effectiveness

The utterances can be categorised according to at least two features: the overhearer's subjective involvement in the representation and whether or not they relate to the maximal elements of the QUD set in Ginzburg's model. According to this perspective, the categories of overhearers' utterances reported in Table 1 can be identified.

These categories are neither disjunct nor exhaustive. However, they suggest a number of questions concerning the appropriateness and effectiveness of the representations of dialogue context.

Is there any relationship between QUD resolution and effectiveness of the exposition, and if so how might such a relationship be evaluated? A relevant question is whether a dialogue episode would gain effectiveness because of QUD getting resolved by dialogue participants' contributions in the sense entailed by Ginzburg's model. The

issue is interesting since the way questions get resolved in the dialogue embodies the relevant message a teacher might want to deliver through the animation. However, resolution of a QUD doesn't entail understanding in an observer. The question can partly be addressed by making the following two points in relation to the resolution of QUD.

1. Negative insights on the representation's effectiveness can come from overhearers' utterances. Utterances that are q-specific to an already decided question point to ineffectiveness of the representation or to overhearer's need of background information. For example, the utterance "But what is the definition for acceleration?", appearing at the end of Figure 12, which is q-specific to the QUD: "Does *a* depend on force?"

2. An episode could also be said to be effective for how overhearers react to (and resolve) QUD it embodies. A restricted set of observers' utterances seems information relevant to other learners, and appropriate for annotating the dialogue. This refers to at least those utterances which 'decide' elements of the QUD. This is the case of the utterance "But friction doesn't matter!" reported in Figure 4.

Can the representation's effectiveness be characterised by finding semantic relationships between observers' utterances and the "accepted FACTS" attributes? According to Ginzburg's model, not all of the QUD that get resolved in the dialogue give rise to "commonly accepted FACTS". Moreover, not all of them can be "accepted" as well by an overhearer. In fact, overhearers' utterances were rarely q-specific to the contextual attribute "accepted FACTS". Their positive contribution to our account is that they emphasise points in the dialogue where the representation is not self-contained, because of the observer raising issues that were meant to be "accepted".

How do the overhearers' utterances relate to the educational goals? A relevant issue is that of determining the way teaching goals should be expressed in the first place, in order to carry out a meaningful evaluation of the "educational effectiveness". Following the categorisation we have chosen (see the table above), the achieving of the same teaching goal (such as "Understand that *a* is irrespective of the distance") can be recognised by overhearers' utterances of different categories (such as "Out_of_context: *a* is constant." or "Projected_out: I was wrong", in Figure 4). This emphasises how, if using overhearers' utterances for evaluating teaching goals, the goals could be stated better by referring explicitly to potential relationships between the overhearer's utterance and either the attributes of the dialogue context, or to facts said or understood earlier by the overhearer. As an extreme example, consider how our perspective of analysis doesn't suit the evaluation of educational goals such as: "Learn how to resolve a misunderstanding" or "Guess who is teaching and who is learning".

Design principles

As has been motivated by the Vicarious Learner Project (e.g. Cox *et al.* 1998, McKendree *et al.* 1998) and related research, a challenging goal is that of supporting the re-use of the animations by enriching them with additional information, including links between episodes that can permit their retrieval. Such richer representations might evolve incrementally and it would be appealing to exploit the observers' utterances for annotating them directly or suggesting how to do it. In fact our data emphasises how what is relevant for an overhearer might be hard to predict. Furthermore, the contribution of learners' experiences has been proved to be extremely valuable (e.g. McKendree *et al.* 1998). From the empirical investigation it is possible to develop instructional design heuristics. Concerning the addition of information to multimedia presentations, a number of problems have been identified. Two types of issues are of concern here.

Minimising cognitive load The first is the limited capacity of information processing of a learner (the overhearer). This concern has explicit psychological foundations in "Cognitive Load Theory" (Sweller 1994). According to Sweller a major impediment to learning is the cognitive load on a limited working memory. The total cognitive load associated with learning depends partly on the information conveyed by the representation. Sweller identifies two types of cognitive load associated with the information source: intrinsic cognitive load concerning the sole intrinsic complexity of the content, and extraneous cognitive load which depends on the presentation format and design of the instructional material. The latter is what a consistent design of the multimedia, in the terms exposed below, can aim at minimising.

Seeking consistency through thematic congruence in multimedia design The second is the matter of how consistency between messages of specific types in multimedia can help to cue users (overhearers) with what to expect. This second problem has been specified in terms of objectives for multimedia design (e.g. those of the ISO 14915, part 3).

According to these issues, in our case, we question what are the properties of the dialogue episodes as a particular type of dynamic media that determine the achieving of these objectives. On the one hand, designing for a presentation format that minimises extraneous cognitive load can be related to the consistency of the presentation format with the dialogue's exchange structure and to the communicative functions it entails. On the other hand, consistency can be sought by avoiding semantic conflicts and imposing thematic congruence (Faraday & Sutcliffe 1997) in the terms of the contextual attributes of Ginzburg's model.

The results of our empirical investigation can contribute in addressing these issues by providing a better definition of control and addressability properties. In particular, as collaborative learning research indicates, there is the need for identifying what range of patterns "contributions" can take. According to Clark and Schaefer (1989), contributions are

addressable elements of information that are responsible for contextual change. They can take a number of "contribution patterns", such as "contributions by turn", by "episodes", by "collaborative completion of utterances", and so on (Dillenbourg *et al.* 1995). Accordingly, the following questions are relevant:

- What are the sub-components of the content that are relevant for an overhearer?
- Are sub-components of the representation addressable?
- If they are, are they addressable directly or indirectly?

Overhearers' comments suggest that sub-components can be identified in utterances. Their direct addressability could be obtained through markers referring to the exchange structure. In relation to the thematic congruence, messages presented in different media (e.g. textual records of utterances by an overhearer or replies to it) should be linked together to form a coherent whole. Coherence can be sought by designing content so it respects the adjacency within the exchange structure (i.e. what might be called the conversational threads) and explicitly relates to the discursive potential through the semantic relations of q-specificity and decidedness. The QUD attribute can be used to exploit how coherence and relevance in dialogic interaction depend on identifying the correct questions under discussion and to assist in placing a speaker's contribution as an answer to such a question. These objectives for multimedia presentation are meant to help design control and usability properties. The empirical investigation suggests the following overhearers' informational needs:

Background information which needs to be available in a timely fashion Background information which is needed by the four overhearers seems mostly to regard the meaning of words. The need of linking such information to particular speakers' turns in a timely fashion is emphasised by the context of its use changing turn by turn (as the definition of a referred to in turn 9 (a=dv/dt) is different from that required for understanding turn 11 (a=f/m)).

Unequal distribution of significant information A number of overhearers' utterances point to the need of knowing speakers' presumptions in order to interpret what they are saying. This need refers to a feature which is specific to dialogue. Differences in what the speakers are aware of often drive the dialogue and can be instrumental to the exposition (e.g. Deirdre's misunderstanding motivates the inquiry in the dialogue episode). Our data suggest further studies on task-based evaluations. E.g., overhearers can take the perspective of a single speaker.

Interest of the overhearer in consequences and reactions to information New issues raised by speakers, as represented by the QUD, seem to be related to overhearers' interest on other potential conversational threads (e.g. "One should think about the force.", "But friction doesn't matter!", in Figure 4). These resources can be used explicitly for keeping track of potential links for further enrichment of the representation.

Redundancy of information necessary for the observer Redundant information seems to be unavoidable, in particular for introducing the episodes. This issue is emphasised by the first overhearer's utterance appearing in Figure 4 ("What does she presume?"), which is a typical occurrence in our data at the beginning of an episode. Some of the necessary information can be said to be 'redundant' because, although it is not part of the dialogue context representation which has been used in this study, it is intuitively present in the vivid representation, or it becomes more explicit very soon.

Conclusion

In the attempt to evaluate how someone learns from the content delivered by dialogue episodes we have emphasised how a critical matter is that of determining what the relevant content for the learner is. The representation of dialogue context used in this study has provided a characterisation of the indeterminacy of the problem, and we have proposed how such characterisation could be instrumental to the design of educational technology.

Instructional design heuristics have been suggested from the empirical investigation by identifying overhearers' informational needs and relating them to the QUD attribute and the dialogue exchange structure. We have shown how the assessment of the educational experience of an overhearer and the characterisation of her informative needs can be informed by complementing an exchange structure account with semantic information. QUD have been applied as a determinant element of coherence and relevance in dialogic interaction.

Further studies

This account would benefit from complementary tools and perspectives of analysis. In particular, the following issues indicate relevant areas for further research:

- *The role of overhearer's background.* The importance of overhearers' prior experience can not be ignored. Interviews and testing on control sets of learners could partly accomplish such evaluation.
- *Influence of the cognitive context constructed by the whole dialogue.* A relevant issue is how the dialogue segments are influenced by the cognitive contexts constructed by the whole dialogue. We didn't consider how the placing and relationships of a segment within a wider context influences the overall reading which is given to it. This is a subtle issue because references to different dialogue segments were often not made explicit by the overhearers. But it is obviously a critical one to the task of learning by accessing different ones.
- By looking at features embedded in the "workings" of dialogue, this approach has allowed for a more objective treatment of the matter. However, there are issues concerning the overhearers' involvement in a broader context

of action which are invisible to our approach. In fact, the matter of what knowledge and experiences we take to be relevant to design has not been informed by accounts of social action. There is a wide range of contexts and purposes with which the dialogue episodes can be accessed.

Since

> ...participants' articulation of their environment is shaped by the activities of the moment, the context that is relevant to what they are doing changes radically when they move from one activity to another... (Duranti & Goodwin 1992, p. 5)

Hence, as a complementary approach to that presented in this paper, an activity-based approach could help informing the design task and be able to highlight contextually grounded implications favourable to practices of social engagement.

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